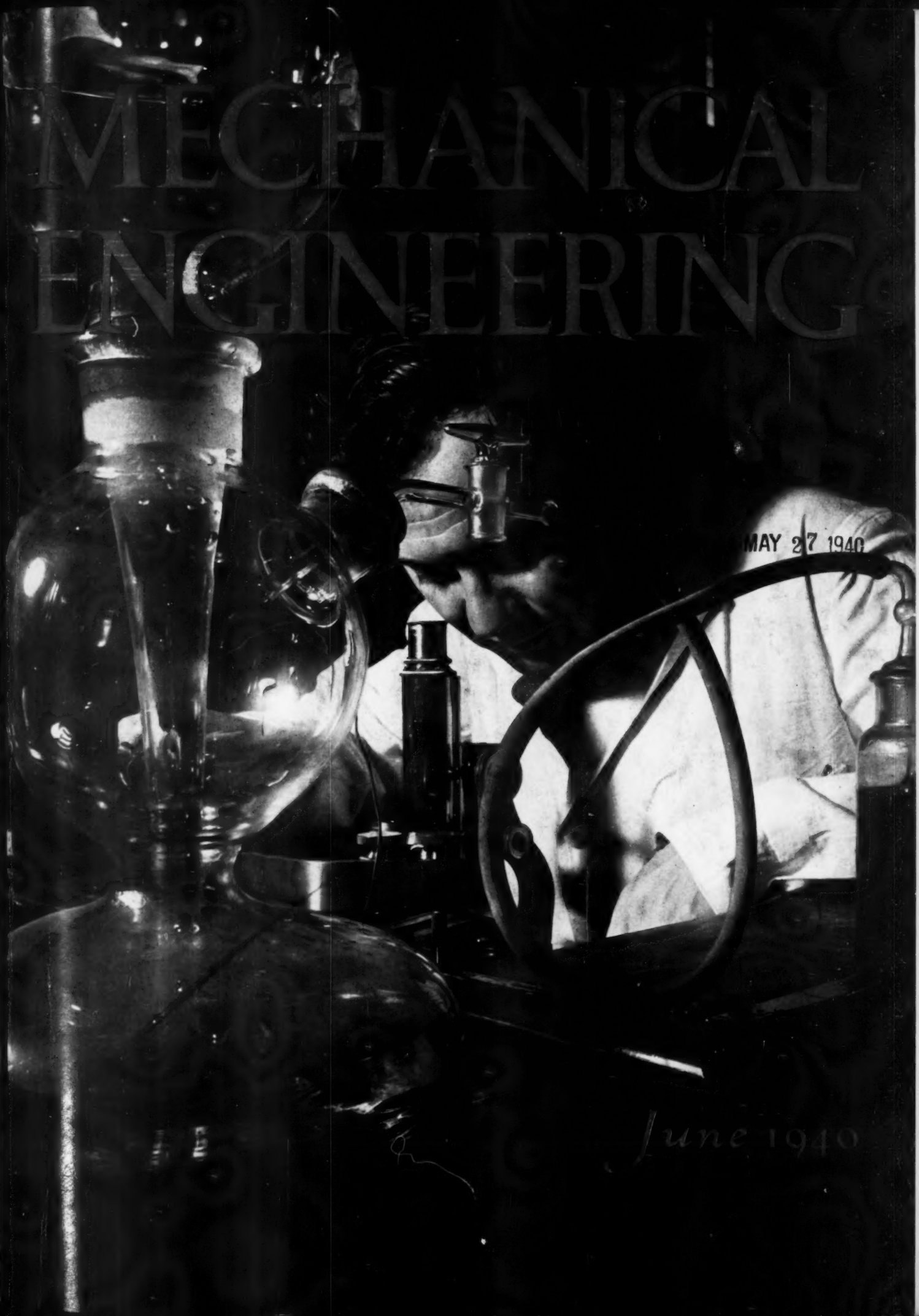
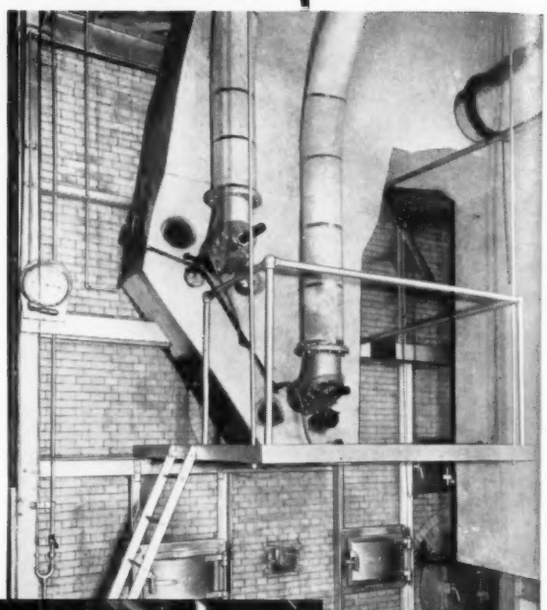
MECHANICAL ENGINEERING



MAY 27 1940

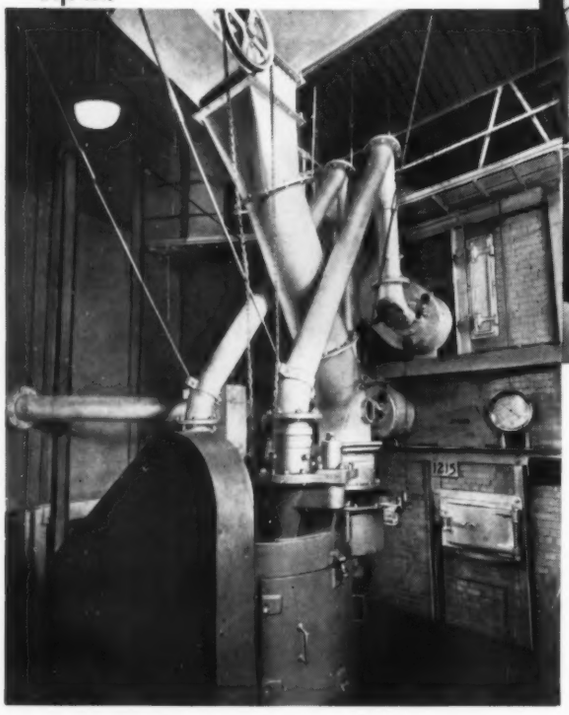
June 1940

These Power Plants *Slashed* Production Costs



$5175 of the annual coal cost was eliminated, 4 HRT stand-by boilers were scrapped, and 18,000 sq. ft. of floor area were saved by a modern steam laundry with this 60,000 lb. steam per hour B&W Integral-Furnace Boiler Unit.

Ten tons of coal per day were cut from the fuel bill when two B&W Integral-Furnace Boilers were put on the line at a large sugar refinery. Capacity of both boilers, 70,000 lb. per hr.; design pressure, 250 lb. per sq. in.



$5000 of the yearly fuel bill and $1000 of the annual maintenance costs were wiped out by this 30,000 lb. steam per hour Integral-Furnace Boiler in a glue and gelatine plant. Design pressure, 250 lb. per sq. in.

Detailed Analyses of These and Other Power Savings Available

The economies cited for these three installations are entirely consistent with those obtained from 260 Integral-Furnace Boilers in service in 201 industrial power plants throughout the country. For this reason, the B&W Integral-Furnace Boiler should be included in any plan for a new or modernized plant.

Further details of this up-to-date boiler design and discussion of performances in the past few years will be sent on request.

THE BABCOCK & WILCOX COMPANY
85 LIBERTY STREET NEW YORK, N. Y.

BABCOCK & WILCOX

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 62 NUMBER 6

Contents for June, 1940

DEVELOPMENT OF EQUIPMENT FOR ROTARY WELL DRILLING . . . . *J. H. Pound* 441
PROGRESS OF HIGHER PRESSURES IN THE INDUSTRIAL PLANT . . . . *W. F. Ryan* 447
EFFECT OF COAL CHARACTERISTICS ON PULVERIZED-COAL FIRING . . . *Ollison Craig* 452
THE CONTROL OF GASES IN THE WAKE OF SMOKESTACKS . *R. H. Sherlock and E. A. Stalker* 455
HARD FACING—A PROCESS FOR THE MECHANICAL ENGINEER . . . . *E. E. LeVan* 459
A STUDY OF HEAT-INSULATION PROBLEMS IN STEAM POWER PLANTS . . . . . *E. T. Cope and W. F. Kinney* 465
APPRENTICESHIP IN THE MACHINE-TOOL INDUSTRY . . . . . *E. H. Neff* 471
READING CLUBS FOR ENGINEERS . . . . . *W. H. Kaiser* 473
STATISTICAL METHOD . . . . . *L. C. Young* 475

EDITORIAL 439
LETTERS AND COMMENT 477
A.S.M.E. NEWS 492
A.S.M.E. BOILER CODE 485
REVIEWS OF BOOKS 490

INDEX TO ADVERTISERS 46

OFFICERS OF THE SOCIETY:

WARREN H. MCBRYDE, *President*

W. D. ENNIS, *Treasurer* C. E. DAVIES, *Secretary*

PUBLICATION STAFF:

GEORGE A. STETSON, *Editor* FREDERICK LASK, *Advertising Mgr.*

COMMITTEE ON PUBLICATIONS:

C. B. PECK, *Chairman*

COLEMAN SELLERS, 3D C. R. SODERBERG

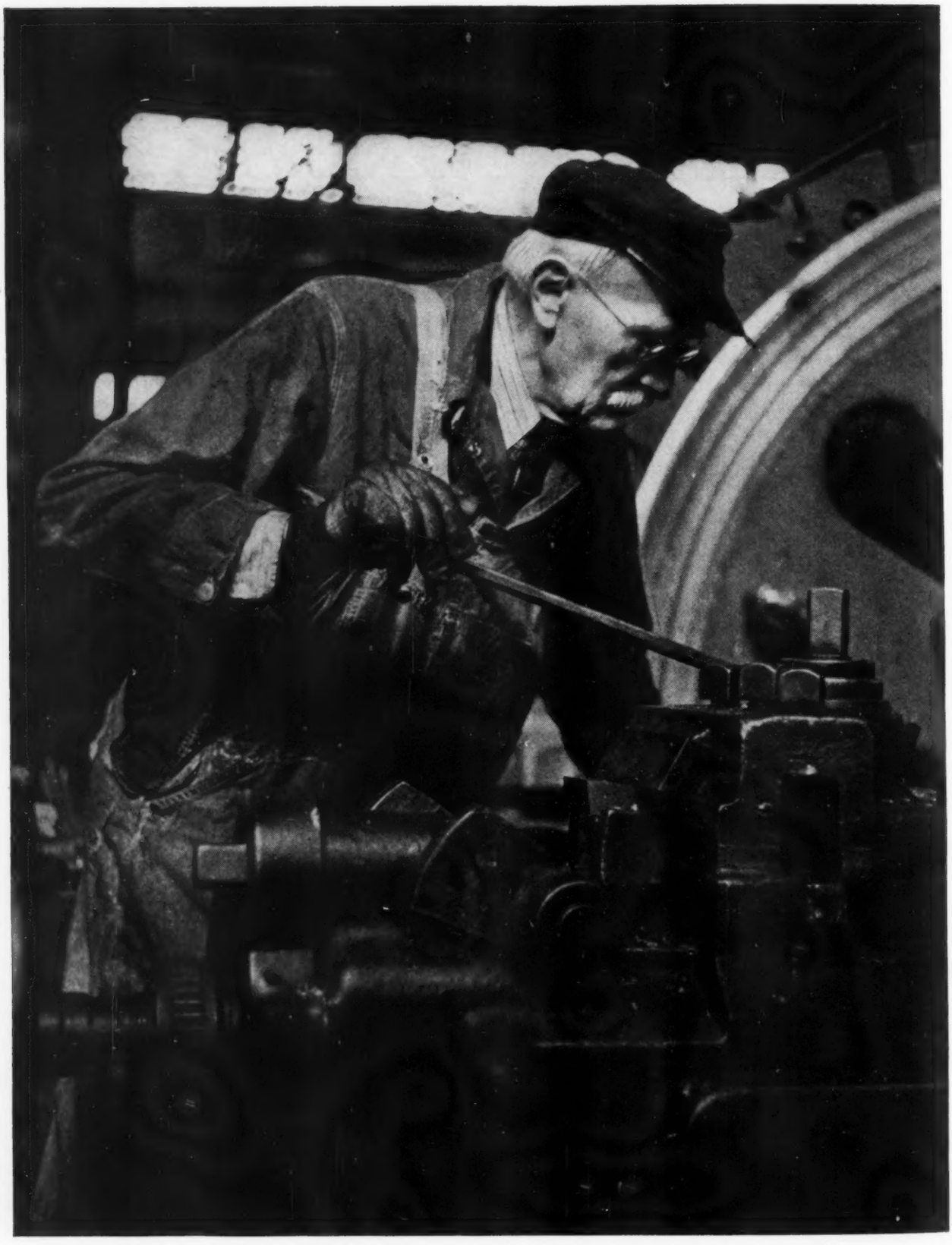
F. L. BRADLEY A. R. STEVENSON, JR.

O. B. SCHIER, 2ND

ADVISORY MEMBERS OF THE COMMITTEE ON PUBLICATIONS:

W. L. DUDLEY, SEATTLE, WASH. A. N. GODDARD, DETROIT, MICH. E. J. KATES, NEW YORK, N. Y. L. S. MARKS, CAMBRIDGE, MASS. J. M. TODD, NEW ORLEANS, LA., N. C. EBAUGH, GAINESVILLE, FLA. Junior Members, C. C. KIRBY, NEW YORK, N. Y., AND H. B. FERNALD, JR., NEW YORK, N. Y.

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1940, by The American Society of Mechanical Engineers. Member of the Audit Bureau of Circulations. Reprints from this publication may be made on condition that full credit be given MECHANICAL ENGINEERING and the author, and that date of publication be stated.



Machinist in Locomotive Works

(Photograph taken by Theodore B. Hetzel and shown at the Fourth Annual Photographic Exhibit held during the 1939 A.S.M.E. Annual Meeting in Philadelphia.)

VOLUME 62
No. 6

MECHANICAL ENGINEERING

JUNE
1940

GEORGE A. STETSON, *Editor*

U-235

TO EACH man, according to his nature and the inspiration of his imagination, the work of scientists with the cyclotron in the attack on the atomic nucleus will have its own meaning. Some will see in the progress of these investigations the development of new techniques of biological study and medical science. To others the tremendous destructive force that would accompany the violent disintegration of the nucleus will suggest a new weapon of offensive warfare. Engineers will be interested in the controlled release of energy for useful purposes—a new source of power. The uncautious will expect immediate and astounding results; the conservative may find himself in the scoffer's seat, once occupied by men of intelligence who thought electricity would never be more than a scientific toy. But events move with such uncertainty that the wise man will be slow to prophesy and will keep his mind open and alert. He will keep his eyes peeled for news about cheap ways to produce U-235 in commercial quantities and what the atom smashers are doing, and he will hope, if success attends their efforts, that man will have learned to control his own energy before he learns how to unleash that of the atom. In the present mad mood of the world it is fortunate that the progress of science is reasonably slow.

Sixty Years of A.S.M.E. Leadership

SIXTY years ago, as everybody knows, The American Society of Mechanical Engineers was born. During the last few months local sections and student branches of the Society have been celebrating this anniversary in a modest fashion appropriate to the temper of the times. No matter what glorious future engineers may face, no matter how close we may be standing, unseeing, to the threshold of that new and better day men long for, the present is dark. We cannot look abroad without apprehension; we cannot look about us at home without misgiving. The situation does not call for idle boasts or fatuous optimism. It calls for a militant faith in institutions and objectives and for courage and wisdom.

History records the fact that The American Society of Mechanical Engineers has been closely responsive to the great forces that have affected the nation and the world. During the era of expansion and industrial development into which the Society was born the activities of the members were principally concerned with problems of technology. When the United States began to make itself effective in international affairs, the Society took the lead among such institutions in broadening its influence in cooperative enterprises at home and in Europe. As evidence began to accumulate to the effect that machine production demanded a technique of management to insure its efficiency, the Society pioneered in providing a forum for the serious discussion of this new branch of engineering art. As the effects of machinery and engineering achievements made the public safety more dependent on sound practices in design and construction, it was the A.S.M.E. that fostered the codes by which the public was protected. In the World War the resources of Society membership were made available to the nation and the allied powers. When aviation was a stepchild of industry, the A.S.M.E. provided opportunity for the discussion and publication of papers on the engineering phases of an infant science that the public was not ready to foster. With the growing consciousness that an industrial era was concerned not only with machines and mass production, but with men and the proper treatment of them, the Society was giving serious attention to educational problems, to questions of wage payment and incentives, to improved working conditions, safety, shorter hours, and labor-saving machinery. In the worst depression of a century, the interests of members of the Society were directed to the causes and cures of economic and social maladjustments.

It would be possible to continue this catalog of evidence to the effect that the A.S.M.E. has always been quickly responsive to the needs of the times but enough has been said to illustrate the point. Today, the Society is concerned with the immediate future and with questions far more grave than any which have faced it in the past. It is no idle prediction to say that the spirit of quick response to external stimuli will exert itself in the near future in a manner that will bring credit to all and prove once again that engineers are able to meet the tests put to them. In what definite and practical manner these tests will be met it is too early to say. Already many members as individuals are at work on problems relating to the national defense, our most compelling immediate task. Unless signs fail, practically every engineer will be so involved almost immediately. Changes in emphasis and routine are inevitable, but as the people of the greatest democracy left in the world awaken to the dangers that threaten them, those who work together in the A.S.M.E. will once more find means of making cooperative effort in a worthy cause effective. Once more the A.S.M.E. will rise to meet the obligations laid upon it by the trend of events. Sixty years of leadership hold the promise of greater services to come.

Design for Living

IN a thoughtful address delivered at the 1940 Spring Meeting of The American Society of Mechanical Engineers, and somewhat humorously called a "Progress Report of an Amateur Economist," Ralph E. Flanders, past-president A.S.M.E., presented a "design for living in America." Opportunity will be afforded in next month's issue to read Mr. Flanders' address and to study his design. Strange as it may sound on the first hearing of it, the design is intended to strengthen, rather than undermine, those virile traits of character essential to the continuance of free enterprise under the capitalistic system, in spite of the extensive, but entirely constructive, role that government is expected to play in it.

Like any other design for living seriously proposed for development and adoption, success in its application depends on many factors, not the least of which is the survival in this country of that capitalistic system of free enterprise we have formerly enjoyed. That this system is threatened from without and within is no secret; and the question arises as to whether the forces of destruction and disintegration already at work will have performed their deadly mission before Mr. Flanders' excellent suggestions can be put into effect.

Whatever design, whether it be Mr. Flanders' or some modification of it the people of this country wish to adopt, it will involve a long-time program of adaptation to its essential elements. It will require the earnest efforts of a sufficient number of honest and resolute men to act as leaders. It will demand a reaffirmation of faith in democracy and a will to maintain the blessings of democracy too frequently assumed today as being some inseparable and natural right that cannot be destroyed. In short, if America is to think seriously about adopting a better design for living it must first guard against the loss of freedom of choice, a loss which may come about either from the forces of totalitarianism pressing from without or decadence of democratic vigor originating from within.

Some decisions undoubtedly will have been made before this issue is off the press. For it seems inevitable that, late as the country has awakened to the dangers that threaten it from without and within, sentiment has grown rapidly in favor of vigorous efforts to strengthen the national defense. The program will probably seem extravagant and wasteful, but it must be remembered that the earlier the cost is met the less it will be and no waste can compare with that of the destruction of American democracy itself.

For years the nation has been building economic cyclone cellars with the paper on which security laws are written. In Europe today similar defenses have been consumed in the fires of invasion. For years we have prattled unctuously of the uses of leisure and have frittered away time, money, and human values in unavailing attempts to put men to work. War has put men to work in Europe. Advertisements in our newspapers feature costumes for "lazing" on the sands. In Europe men and women lie unburied on the sands. The thing that couldn't happen is happening. How silly to talk of three-day work weeks with a navy to be built and airplanes and defensive weapons needed in unbelievable quantities. If we are to have a design for living, it must include a design to defend the right to live, and if it is to be a design based on American ideals of democracy, it must first guarantee the survival of that democracy.

What They Think at Purdue

IN a world that has abandoned so many of its former ideals it is easy to believe that youth may lead the way in breaking away from traditional attitudes and in seeking desperate short cuts to objectives born of lost faith and shattered virtues. The times are ripe for discontent brought about by frustration of faith and ambition. What is more natural than that youth, contemplating an uncertain future, should seek its own methods of salvation? With failure and cynicism dogging the steps of their elders, can young men be expected to accept the moral and spiritual values of a former age without question?

It is heartening, therefore, to read the factual report of John K. Bryan, member of the A.S.M.E. Student Branch at Purdue, on the results of questions he put to 264 of his classmates at that institution. The fact that these questions related to the article "Unionization of Engineers," by James H. Herron, that appeared in the November, 1939, issue of MECHANICAL ENGINEERING and to the letters discussing the paper that have been published in more recent issues, adds to the interest in the answers.

Mr. Bryan, in a paper read at the A.S.M.E. Group V student conference at Purdue reported that 85 per cent of the students replying to his questions believe that engineering is a profession. Only 11 per cent think it is not, and the remainder are uncertain. Furthermore, the replies indicate, less than one fifth of these future engineers think that engineering is closer to labor than it is to management, and only 11 per cent favor unions for engineers. This latter figure is reduced to 3 per cent when only members of the A.S.M.E. student branch are considered. Here is an indication of faith in the high quality of the service engineers are supposed to render to society, a service on a professional level that is distinctive, with implied ideals and obligations.

But as reassuring as the foregoing replies may be of the caliber of engineering students at Purdue, greater significance attaches to replies to other questions. Ninety per cent of these young men told Mr. Bryan that they are going into engineering because they think they will like it; only 12 per cent answered that money was a consideration; and to the question, "Are honor and recognition by fellow engineers as important as salary?" eighty-one per cent answered, "Yes."

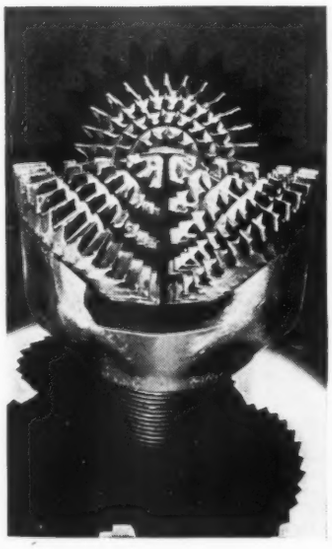
Back of the answers to these questions are many influences. Chief of these are parents and the home and the intellectual environment and moral atmosphere of the university. It would be hard to think that a nation is doomed to decadence when its homes and its educational institutions can implant and sustain such ideals in an age when whole peoples have gone morally mad.

Development of Equipment for ROTARY WELL DRILLING

History of Rotary System in Petroleum Industry, 1900 to 1940

By J. H. POUND

THE RICE INSTITUTE, HOUSTON, TEX.



MODERN ROTARY BIT
(Courtesy Hughes Tool Co.)

PRESENT-DAY civilization is so dependent upon a plentiful supply of petroleum, sulphur, water, and the salts of sodium and potassium that our ability to reach strata containing these materials is a matter of national importance and one engaging the activities of thousands of engineers. Because such materials often exist at great depths below the surface, the cheapest method of securing them is not by the usual mining processes but by drilling small-diameter wells, dissolving or melting those substances not already liquid, and pumping the fluid to the surface. In such operations, depths of almost three miles have been attained. The present record is 15,004 ft with the lower 2200 ft of hole only 6 in. in diameter. Depths of two miles are very common. In drilling such holes, engineers have also unearthed an increasingly great number of interesting technical problems.

EARLY DRILLING PROCESS IMPROVED

Today, most of these holes are drilled by a relatively recent process, the rotary system. In its fifty years of life, the effectiveness of this method has been tremendously enhanced by those using it who have ever been alert to develop or adapt from other fields an almost endless succession of improvements in materials, manufacturing methods, and operating technique. Its history is both coeval with that of the automobile and rather similar in its rapid technical development. Moreover, though well drilling seldom touches men's lives as directly as does the automobile, the unspectacular service of petroleum producers has had a tremendous effect upon our comfort and mode of living. Since the influence of the gasoline engine is dependent upon a cheap source of liquid fuel, it is quite fair to list the rotary well-drilling system as an important member of the group of technical developments giving us today's highway, marine, and aerial transportation. The history of the machinery and methods used by this system constitutes a record replete with ingenious solutions of difficult engineering problems.

The earlier system of well drilling churned a chisel-ended heavy bit up and down in a relatively dry hole, the resulting chips and loosened material being removed periodically by adding water to the hole and then bailing it out with a long slender bucket, the bottom of which contained a check valve. Both the bailer and the bit were hung from ropes, hence the name "cable tool," widely applied to this system. Its beginnings are lost far back in history, and it is still used where the underground strata are hard and self-supporting. However, in soft formations drilling with cable tools is a slow process, while another fault of the system develops when the walls of the hole tend to cave in. Then expensive pipe (casing) must follow the bit or else a different system of drilling must be used. In cable-tool drilling, sticking of the casing or the need for excluding flows of water or gas often requires the setting of several concentric strings of casing, each string extending down from the surface past the troublesome formation. The expense involved in this procedure is obvious.

EQUIPMENT ESSENTIAL TO ROTARY SYSTEM

In soft formations, scraping action digs faster than percussion, but radically different machinery is required. By 1890, drillers of water wells were using equipment which incorporated the essentials of the rotary system. These include a long vertical pipe (the drill stem) to the lower end of which is screwed a flat vertical blade with cutting edges at the bottom and sides. This pipe is revolved by a rotary table on the derrick floor. Water pumped steadily into a swivel at the upper end of the pipe emerges through holes in the bit and, by rising to the surface through the annular space between the walls of the hole and the outside of the drill pipe, carries the cuttings to the surface. By charging this circulating water heavily with clay or other suspended solids the drillers achieve two useful effects, namely, (*a*) the "mudding up" and supporting of those strata having a tendency to erode or cave into the hole, and (*b*) the provision of a dense hydraulic column the weight of which diminishes the

HARD-FORMATION CORE BIT
(This bit formed in 1938 the bottom of a hole 6 in. in diameter at a record depth of 15,004 ft. Courtesy Hughes Tool Co.)

LUCAS OIL WELL AT BEAUMONT, TEXAS
(Courtesy the American Institute of Mining and Metallurgical Engineers.)

risk of high-pressure gas or liquids straying from one stratum to another or even blowing the drill pipe itself out of the hole.

Both the mudding and the pressure-control effects diminish the amount of casing required by the hole. The pumps handling this slush must be capable of resisting gritty fluid and of developing hydraulic pressures which, today, are sometimes as great as 5000 lb per sq in. Of course a strong derrick, steel cables, pulleys, and a hoisting winch (called draw-works) are required for lifting and lowering the drill pipe and any casing required. Engines or motors must also be supplied for driving the circulating pumps, rotary table, and draw-works.

As the hole deepens, the drill pipe must slide freely through the grips on the rotary table while the latter turns, and, eventually, additional joints of pipe must be screwed to the upper end of the drill stem. Replacing or sharpening the bit requires hoisting the pipe through the central hole in the rotary table, supporting it there by wedges known as slips, unscrewing it into sections between 40 and 80 ft long, and stacking these "stands" on end inside the derrick with the aid of a man working high up in that structure. The process is reversed when running the pipe back into the hole. The time required for a "round trip" in a deep hole is so considerable, even with a well-trained crew, that it compares unfavorably with the speed of reeling up a bit on a wire line. In addition, the necessity for making and breaking fluidtight joints repeatedly between stands of drill pipe imposes severe conditions on these threaded connections. But with all its faults, the rotary drill stem digs most American wells.

DRILLING IN HARD ROCK FORMATIONS

When hard rock is met, the flat fishtail or drag bit is replaced by a rock bit in the form of a vertical steel cylinder the lower end of which carries hard-steel cylindrical or conical toothed cutters, shaped somewhat like machine-shop milling cutters. These cutters are mounted to turn freely on shafts and, as the drill pipe is rotated, they are moved by contact with the bottom of the hole. This rotation brings new teeth in contact with the rock. Coats of tungsten carbide, stellite, or similar hard-facing materials are widely used to prolong the life of cutters and bit heads. The pressure concentrated on the rock which is in contact with the crest of these teeth makes a hole faster and with less bit wear than when purely scraping tools are used, even when the latter have the best heat-treatment or hard-facing protection. Sometimes, either toothed cutters or flat blades are arranged to remove an annular ring, leaving in the center of the hole a projecting core of rock or soft formation which can be gripped by ratchetlike fingers and lifted to the surface for geological examination.

The mechanical characteristics of the equipment used by this rotary system have always been determined primarily by the severe demands placed upon it. Loads are heavy, complex, and hard to predict; possible cross sections of the metal carrying these loads are often limited, especially by the small diameter of the hole being dug; original dimensions of equipment are quickly reduced by the erosion of liquids, the abrasive action of hard rocks, and corrosion. The ordinary dead-weight stresses due to the weight of two or three miles of vertical pipe or casing can reach around 200 tons and are bad enough in themselves; but when these pipes "freeze" in the hole, much greater loads may be placed on the derrick, hoisting equipment, and the pipe itself. During the drilling, trouble is added by torsional stresses, reversed stresses, repeated stresses, and stresses concentrated at the roots of threads. In addition, the high static pressures needed in the drilling fluid and those developed inside the hole by formation conditions must be resisted. The ambitions of oil producers to reach greater depths and to penetrate more difficult strata have continually increased these difficulties.

Improved equipment is also made highly desirable by the financial risks involved. The drilling of one hole can run up an expense of perhaps one hundred thousand dollars, and the failure of equipment can cause the hole to be lost with the bit near or even in the pay sand. The combined severity of drilling service and heavy financial risks give point to the manufacturers' slogan, "nothing is too good to go in the hole," a statement which holds equally well for materials and for design quality. Well-chosen drilling equipment is, therefore, usually not cheap in any sense of the word.

FACTORS INFLUENCING DESIGN OF EQUIPMENT

As usual, a variety of other nonmechanical limitations have affected the equipments. Forty years ago, the safety of humans was a matter left chiefly to individual workers. In the oil fields today, workers' risks are really considered in the selection of machines and structures. Abuse of machinery is still too common. The members of the drilling crew have never been men accustomed to handling equipment delicately; there has always been good reason for applying the name "roughneck" to the laborers on the derrick floor; so machinery must be designed with a high abuse factor. The desirability of providing a high load factor on an assembly of equipment, the first cost of which may total one hundred and fifty thousand dollars, encouraged the use of unitized devices capable of rapid assembly and easy transportation. Sometimes even the derricks themselves are skidded in one piece from location to location in tow of a tractor or heavy truck, over considerable distances and across such

obstructions as railroads and mountains. Since perhaps as much as 500 tons of equipment and pipe must be hauled to the site of a deep well, highway limitations on weights and on over-all dimensions of individual equipments plus the decidedly rural location of most wells also have had their effects on equipment designs.

Moreover, in the United States a great change in economic conditions over this 40-year period has altered equipment very noticeably. Legal limitations on the quantity of oil each well may produce daily makes economy in drilling a matter of first importance. The "gold-rush" methods which, as late as a dozen years ago, were characteristic of drilling in newly discovered fields have largely disappeared in favor of planned and economically justified engineering processes. It is true that the wildcat rigs are still with us, with their "poor-boy" equipment and with more of high hopes than scientific knowledge; but, in general, the well drilling of today rests on a substantial foundation of sound engineering in both machinery, methods, and exploration. For example, economy in power consumption was once completely ignored in the oil field, but the popularity today of superheaters, antifriction bearings, careful lubrication, and Diesel engines indicates that the era of waste is nearly over.

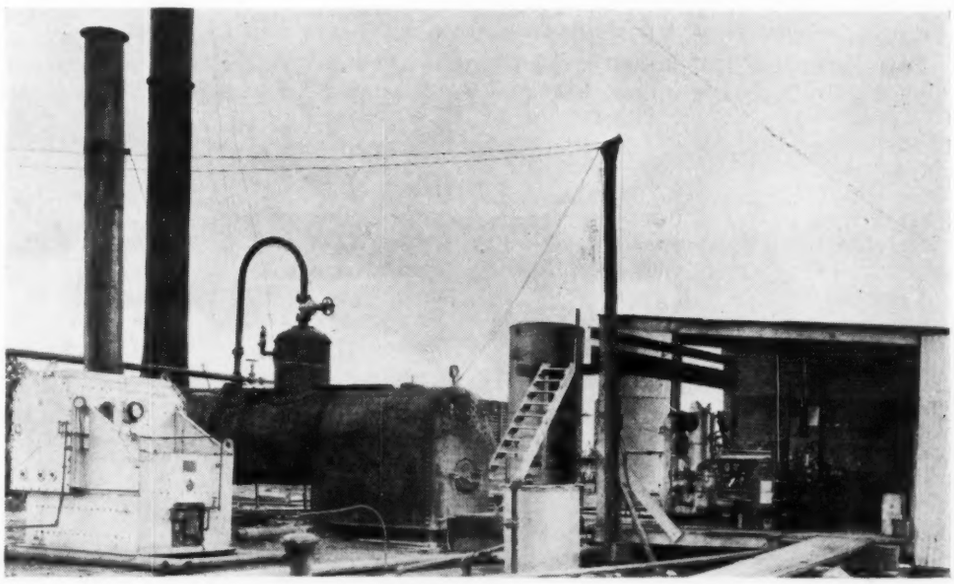
BRINGING IN A GUSHER WITH THE FIRST ROTARY RIG

How completely rotary well drilling has changed during this 40-year period may be more readily appreciated by contrasting today's equipment with that used on a well which made drilling history in 1900. About October 1, of that year, at Spindletop, a mound near Beaumont, Texas, in the flat plain some 30 miles north of the Gulf of Mexico, a crew of 4 men entered a lease owned by Captain Anthony F. Lucas. They had been brought from the shallow oil fields of Corsicana, Texas. One of these men, Curt G. Hamill, is still alive and has furnished the author with many details of the equipment on this job. Hamill Brothers had contracted to drill a 1200-ft hole at that location. With heavy water-soaked lumber, they began the erection of a small derrick 74 ft high, 18 ft square at the base, 4 ft square at the top, and with an estimated strength of 75,000 lb. The crown block was of oak timbers in which were cut grooves to hold the shafts of the crown sheaves. They placed one 30-hp Fare and Treft locomotive-type boiler, a 9 × 12-in. twin reversible Wolf steam engine, two 8 × 5 × 10-in. Smith Vaille steam pumps, a 12-in. Chapman rotary table, a 3-sheave traveling block made of wood and strap iron, a draw-works with a $3\,^{15}/_{16}$-in-diam drum shaft, and fishtail bits attached to 4-in. standard pipe. The pipe was broken up into stands about 40 ft long which were connected by ordinary pipe couplings. Finally they dug a water reservoir, strung up $2\,^{1}/_{4}$-in. manila drilling cable, and, by firing saw-mill slabs and cordwood under the boiler, they built up a steam pressure of 90 to 100 lb. In the absence of modern truck winches, this rigging-up was doubtless very heavy work. Mules were usually included in oil-field landscapes of that day, and on this lease they probably did much of the hauling and hoisting which today is performed by the energy of gasoline.

Drilling began about October 27. Contrary to present-day practice, digging was done only in daylight, though below 520 ft, water circulation was maintained at night. As the bits wore, they were dressed back to gage and sharpness at the rig. Rock bits were not to be developed until about 1909, when the efforts of Howard Hughes, Sr., and others would begin to make them common tools. The formations met at Spindletop were clay, sand, or shell, and caving troubles were numerous. Three joints of 10-in-diam surface casing were set; then an 8-in. hole was drilled to 260 ft, where the circulating water ceased to return to the surface. It was escaping into a 20-ft stratum of coarse gravel. Then a valuable practice was initiated: The bottom of the water reservoir was plowed up and mud was pumped instead of relatively clear water. This sealed off the porous formation. The 8-in. casing was carried down to 420 ft, though for the last hundred feet it had to be hammered down by a heavy timber block lifted by the draw-works through a cathead line.

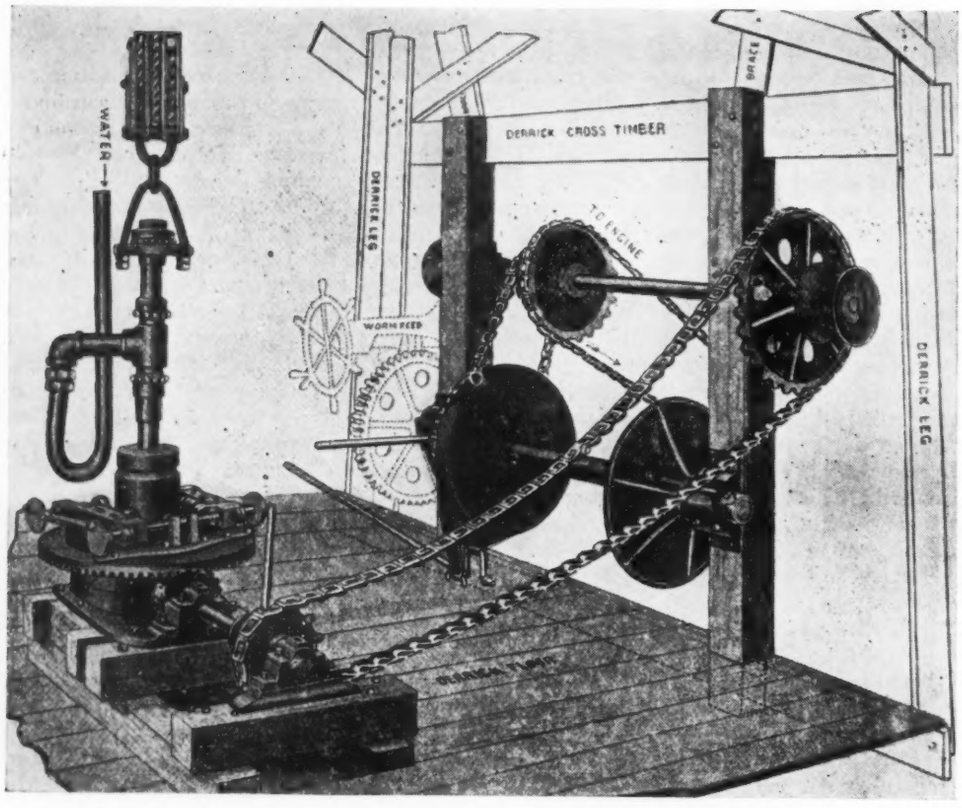
Once more the size of the bit was changed and by Christmas Eve a 6-in. casing string had been set at 920 ft. The crew returned home for a week's rest during the holidays, but on New Year's Day they were again drilling through the 6-in. casing. At 1050 ft gas began to bubble up the casing; and at 1160 ft, on January 10, 1901, while a sharpened bit was being lowered, the drill pipe reversed its motion and began to rise from the hole. Curt Hamill, the derrick man, was able to descend before the five or six hundred feet of 4-in. pipe skyrocketed through the top of the derrick. It broke in two pieces and fell without injury to derrick or crew, but it was followed out of the 6-in. casing by an uncontrollable rush of gas, rocks, and oil which quickly turned into a column of oil twice the height of the derrick. The rotary system had produced its first oil gusher.

The drillers soon discovered that no valves suitable for controlling such a flow existed in the neighborhood. The nearest supplies were in St. Louis; so little could be done for some time except to trap the oil in earthen levees and hope it



TYPICAL INSTALLATION OF A SEPARATE OIL-FIRED PORTABLE SUPERHEATER OPERATING IN CONJUNCTION WITH A 350-LB OIL-FIELD BOILER

(Courtesy Oil Well Supply Co.)



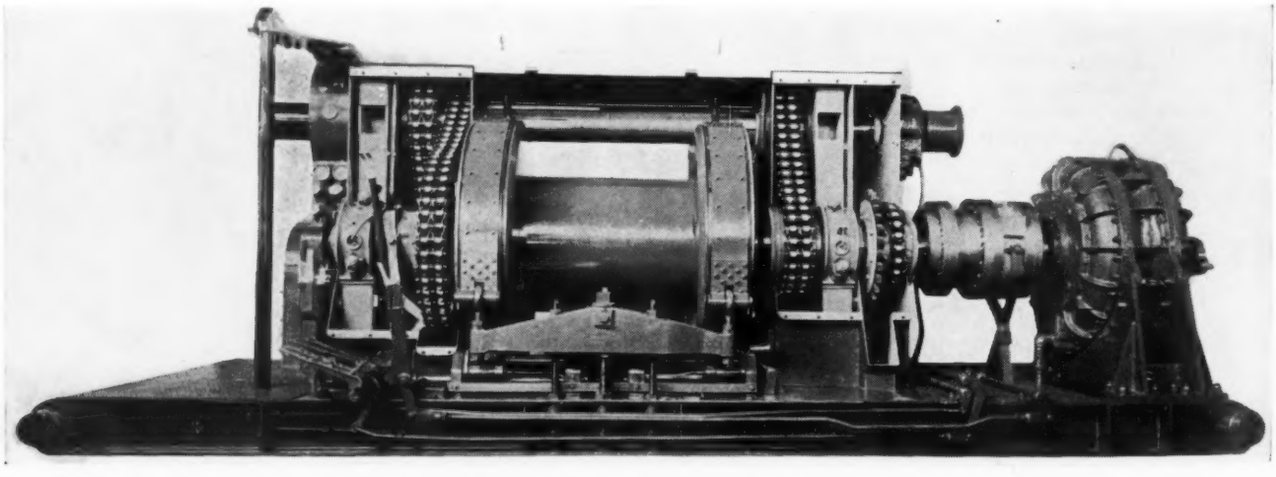
EARLY DRAW-WORKS, ROTARY TABLE, SWIVEL, AND TRAVELING BLOCK
(Courtesy Oil Well Supply Co.)

would not ignite. Oil spray painted the entire neighborhood, including the visitors who arrived in great crowds on special excursion trains. Local newspapers commented on the presence of one adventurer who drove to the well in an automobile. The gusher was not brought under control for 9 days. Then the shut-in pressure of the oil at the surface was proved to be only 104 lb per sq in.

MODERN METHODS OF CONTROLLING FLOW

Today, drilling a 1200-ft well in soft formation and controlling a 104-lb pressure without loss of oil would be quite simple in south Texas; in fact, depths of 10,000 ft and pressures of several thousand pounds per square inch are not remarkable in the Gulf Coast fields. Mud with a specific gravity of perhaps 1.3, made with special heavy solids instead of local clay and, possibly, with a colloid material added under the control of a graduate chemist, would usually hold back the formation pressures. If the drill pipe began to rise, horizontal pistons in cylinders mounted on the top of the casing (blowout preventers) would be closed quickly against the pipe by water pressure from the pumps or by steam pressure or by man power. If necessary, valves capable of withstanding 10,000 lb per sq in. pressure safely could be secured. The flow could be restricted without a dead shutoff through the use of hardened-steel orifices (flow beans), attached either at the surface or at the bottom of the hole. Today, the time required for duplicating the Lucas well would perhaps be less than one fourth of the 13 weeks actually required. The equipment used would, by contrast with the 1900 type, give a fair measure of 40 years of general engineering progress in metallurgy, machine design, and manufacturing methods, as well as in special drilling practice.

If the Hamills had possessed today's excellent equipment for lifting cores from the bottom of the holes in both soft and hard formations, Captain Lucas could not have made his complaint, "the hydraulic system of boring . . . . proved quite unsatisfactory as to the accuracy of the record . . . . of the strata traversed." But though he knew very little about conditions

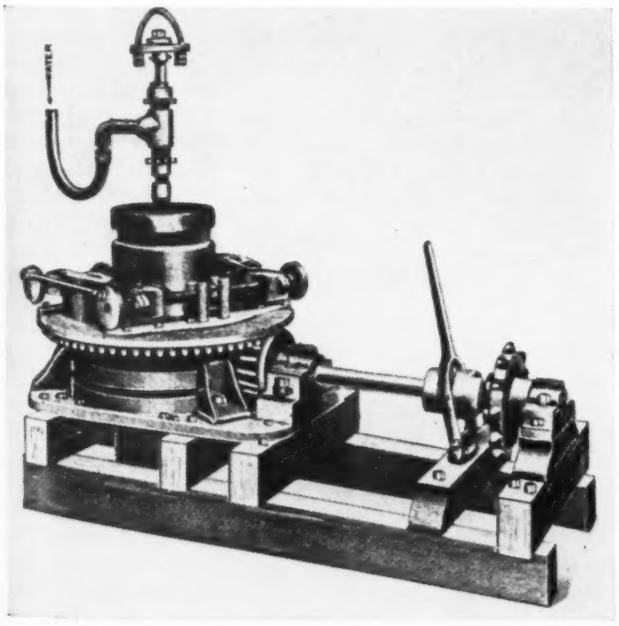


MODERN TYPE OF UNITARY DRAW-WORKS EQUIPPED WITH BOTH HYDRAULIC AND MECHANICAL BRAKES. GUARDS REMOVED
(Courtesy Emsco Derrick and Equipment Co.)

at the bottom of his well, he was spared one type of today's troubles, namely, that due to serious deviation of the hole from the vertical. His well was probably too shallow to accumulate such distress, though wells only 4000 ft deep are said to have wandered over 60 deg from the vertical. Today, drillers can keep "dog-legs" out of the drill stem quite well by such methods as regulating the pressure on the bit through weight indicators attached to the supporting wire cable. In fact, today's deepest well has a maximum deflection of only $2^1/_2$ deg. Instruments (sometimes of the gyrocompass type) lowered by a wire line allow a photographic survey record to be made in a crooked hole with considerable ease and, if necessary, the wandering section of hole can be eliminated by sidetracking or plugging and redrilling. Captain Lucas probably never heard of "directional drilling" or of pumping large quantities of Portland-cement grout into wells, or of bottom-hole pressure and temperature measurements; yet, the modern driller knows the processes well. Captain Lucas also drove his casing past small oil shows with no hope of securing this oil; but, if his well had proved a "duster" at the lower depths, he might today have lowered a gun perforator to the proper level and by electric control he might have fired steel bullets through the casing, opening a way into the producing sands previously sealed off. But such methods, though popular enough today, have been developed only in the last 10 years.

FEWEST CHANGES MADE IN STEAM POWER PLANT

The steam power plant probably would show as few changes as any part of the drilling rig, but today's deep wells would use four or five boilers, each of 125 rated hp. They would be oil- or gas-fired, well-blanketed with removable insulation, probably supplied with feedwater heaters and superheaters, and would generate steam at perhaps 350 lb and 500 F, though these figures are exceeded on some rigs today. The hoisting engine might be a 12 × 12-in. twin, developing perhaps 800 hp at 400 rpm. The two or more drilling pumps might be about 15 × $7^3/_4$ × 20-in. duplex direct-acting units, piped in series to compound the fluid pressures, and equipped with replaceable pump valves. Their pistons and cylinder liners would be of special abrasion-resisting materials, with the liners possibly of centrifugally cast nickel iron. Perhaps the pumps would be driven through modern V belts by more economical engines than those with direct-acting steam cylinders. Power economy could also be secured by driving the rotary table by a separate 300-hp engine instead of an underloaded hoisting engine, acting through the draw-works and several chains. Drilling would continue at night under electric light supplied from steam turbogenerators of 2 or 3 kw capacity or from internal-combustion lighting units. Lighting fixtures would be vaporproof, to avoid igniting gas from the hole. In most locations, the boilers would have to meet A.S.M.E. and state legal requirements.

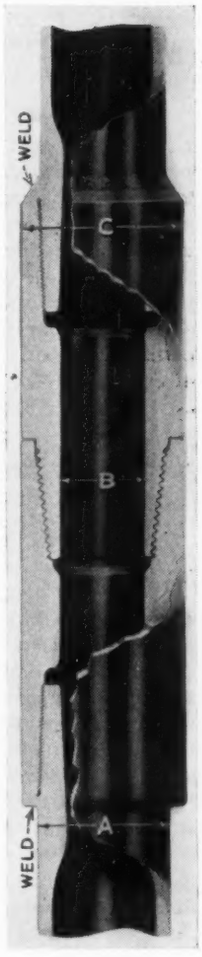


CHAPMAN'S PATENT HEAVY XX ROTARY, FROM A CATALOG DATED 1901

("This is the latest improved pattern manufactured by the American Well Works . . . . the size best adapted to the Texas oil fields will handle casing or pipe from 12-inch to $2^1/_2$-inch inside diameter. Approximate weight 1800 lbs.")

DEVELOPMENTS IN DERRICKS, DRAW-WORKS, AND ACCESSORIES

Derricks are made today of galvanized-steel angles, frequently attain a height of 136 ft, have 30-ft-square bases, and are capable of resisting a 70-mph wind. As in the case of a great deal of the rotary equipment, they are designed with strengths and major dimensions standardized by the American Petroleum Institute. The swivel used today is sometimes capable of holding a 300-ton load while the drill stem rotates at 250 rpm. Manila rope has given way to $1^1/_8$ to $1^1/_4$-in. steel cables, strung through steel traveling blocks which are perhaps 7 ft tall. These traveling blocks hold four or five sheaves, made of wear-resisting manganese steel, which are mounted on ball or roller bearings.



FULL-HOLE TOOL JOINT WITH STANDARD A.P.I. PIPE THREAD. COUNTERBORE WELDED

(Courtesy Hughes Tool Co.)

The modern draw-works is very different indeed from its predecessor. Instead of being shipped to the rig in small pieces and there assembled on wooden posts framed into the derrick structure, it is now completely unitized and mounted on skids, even though this practice may make it an assembly weighing about thirty tons. Its several parallel shafts, supported on roller bearings and equipped with flame-hardened or manganese-steel sprockets and jaw clutches, provide perhaps eight hoisting speeds, plus one or two speeds for the chain driving the rotary table.

The hoisting-drum shaft on one design is 10 in. in diameter and 14 ft long. Just as the oak blocks, once forming the brake linings for the hoisting drum, had to give way to asbestos compositions, so today the heavy water-cooled friction brakes are requiring aid from hydraulic types like the simple fluid-friction water brakes used for turbine testing.

The rotary machine of any date is essentially a heavy-duty horizontal thrust bearing driven by bevel gearing; but today the gears are made of alloy steel, sometimes have spiral bevel teeth, and always are safely housed and reliably lubricated. The modern table is about 5 ft in diam, weighs perhaps 5 tons;

and may be supported on balls 3 in. in diameter. The 1900 rotary table weighed about 1 ton and was made chiefly of cast iron, a material which has small application in drilling equipment today.

The early rotary table carried four vertical driving rings the sharp edges of which gripped the uppermost joint of drill pipe, caused its rotation, but weakened the pipe. These rollers have been completely replaced by a bushing in the table through which a long forged-steel bar slides vertically. This bar is square or fluted, perhaps 7 in. square × 51 ft long, with a large-diameter hole bored through it to carry the mud. This "Kelly joint" regularly occupies the upper end of the drill stem, the added stands of pipe being screwed on below it. Like so many parts of the modern rig, it is made today of heat-treated chrome-nickel steel. The A.P.I. standards require a bar 10 ft long, $^1/_8$ in. below nominal diameter to pass freely through the bore; so the manufacture of Kelly joints requires a neat job of deep drilling in the machine shop.

IMPROVEMENTS IN JOINTS

Another device common today but not on the market until about ten years after the Lucas well was drilled is the tool joint. This is a special threaded two-part hollow connector taking the place of a pipe coupling but with each half more or less permanently fastened to the end of a drill-pipe stand. Its appearance of simplicity is highly misleading. Since the pipe stands must be repeatedly connected and disconnected, both the male and the female threads must be of rugged design, must be formed in strong, wear-resisting, and nongalling material, and must be manufactured to such close limits that no wabble exists when the halves are screwed up to form the necessary watertight joint at their shoulders. They must of course also be completely interchangeable in a given size and type. To meet the requirements of a quick make-up or release (say in four turns), tool-joint threads are coarse and have a rather sharp taper, perhaps 3 in. per ft. Usually they are formed by hobbing.

Ordinary pipe steel will not meet the strength and hardness requirements of this joint; so hundreds of tons of carefully heat-treated alloy steel are forged and machined into tool joints annually. By welding them to the drill pipe, it is possible to avoid the bad stress concentration usually existing where the end of the tool joint ceases to engage the thread on the drill pipe.

Sometimes the tool joints are protected from the abrasion of the walls of the hole by forcing a rubber sleeve over their outer surfaces. To minimize the pressure drop experienced by the circulating liquid, the tool-joint bores are today streamlined as much as strength requirements permit.

FACTORS WHICH CONTRIBUTE TO SUCCESSFUL DRILLING

Much of the success of today's drilling is due to improved drill pipe. A drill stem 3 miles long will weigh over 120 tons; yet, when one considers that it may be only $3^1/_2$ in. in outside diameter and with a wall thickness of only $^3/_8$ in., a drill stem of that length appears as a rather flimsy member, capable of peculiar vibrations and unpredictable kinks. Since its upper end will be rotated at 100 rpm or more, while its lower end may be stalling and jerking around erratically among boulders, its torsional experience can be very severe. To minimize some of its faults and to produce a straighter hole, one or two hundred feet of thick-walled forged tubing (drill collars) are now hung directly above the bit. This practice supplies stiffness at that point, plus enough weight to keep the entire drill stem straight and in tension by draw-works pull, while simultaneously pressing the bit hard enough against the bottom of the hole by the dead weight directly above the bit. In effect, the drill stem must be a taut plumb-bob string as well as a very long torsional member rotating a bit; so the desirable strength and toughness of drill pipe would be limited only by its cost. Captain Lucas' well was probably drilled with ordinary lap-welded merchant pipe, possessing an ultimate tensile strength of perhaps 58,000 lb per sq in., but today seamless-steel pipe with a minimum tensile strength of 95,000 lb per sq in. is readily available. It is often made with special upset ends to supply metal where the threads remove strength. The day may come when the pipe mills will eliminate tool joints by producing a sufficiently cheap drill pipe with threaded ends showing properties as good as modern tool joints. The latter often have a yield point of 125,000 lb per sq in. and a Brinell hardness of 300.

MANY FIELDS OF ENGINEERING INVOLVED

Engineers from many fields have contributed to this record of progress. The metallurgist has probably been as valuable an assistant to the petroleum producer as to any other user of machinery. One of his most appreciated contributions is the group of hard-facing metals so commonly used to minimize the wear caused by hard rocks; and the immense help given the driller by alloy steels and heat-treatments developed since 1900 is beyond appreciation.

In a somewhat similar way, changes in manufacturing technique have provided better tools. Gas and electric welding have proved especially valuable processes, their applications extending even to the welding together of the ends of the casing as it is lowered into the hole instead of screwing the lengths together in the usual manner. Reliable cast steel, gas carburization, better forgings, improved machining methods, and mass manufacturing operations all help the driller in his battles against geological conditions, the economics of oil proration, and the drillers of competitive offset wells on the lease next door.

MODERN METHODS HAVE NOT ELIMINATED ALL THE EXCITEMENT

Some persons may regret the apparent loss of color and excitement following the substitution of science and investigation for the former conditions of guesswork and uncertainty. However, those close to the task of the deep-well driller and to the problems of the men supplying him with equipment still discover plenty of excitement and suspense in their work with well-drilling machinery. In spite of improvements, unsolved problems still cause spectacular and serious damage. Blowouts still shoot drill stems out the top of the derrick, force the derrick men to slide down guy lines, and coil hundreds of yards of drill pipe over the surface of the lease; zealous drillers still pull derricks in on their heads; others twist off drill pipe and perhaps block a costly hole already 2 miles deep, then perhaps save it by sidetracking it above the lost pipe; very hard metal junk still falls into holes and causes fishing jobs which delay drilling for many weeks; wells still run wild, ignite, and form a rumbling volcano endangering an entire field; pump cylinders, fittings, and boilers explode; lightning, hurricanes, and shifting underground strata play weird tricks. Even if no trouble is anticipated, the day when the drill enters a producing formation or when a new piece of equipment is to receive its test overload is a day of over-the-top tension. The men doing such work are fighting Nature, often with too little knowledge of their foe. To provide economical conditions while sinking a 6-in-diam hole 3 miles deep into the earth, down to black depths which have perhaps been unlighted since before the days of man, is a real job. Both in the process of drilling and in the process of designing and building the equipment needed for this fight, 1940 engineers live through as many exciting moments as those experienced by the drillers of the Lucas gusher.

PROGRESS *of* HIGHER PRESSURES *in the* INDUSTRIAL PLANT

By WILLIAM F. RYAN[1]

MECHANICAL ENGINEER, STONE & WEBSTER ENGINEERING CORP., BOSTON, MASS.

THE first A.S.M.E. paper[2] on the value of higher steam pressures in the industrial plant was presented at the Annual Meeting in 1925. From a present-day point of view there were no high-pressure industrial power plants at that time. Published records disclose only eight installations with a total capacity of 13,425 kw then operating at pressures above 275 psi,* and the highest pressure was 350 psi. One manufacturer[3] had installed a small 1250-psi boiler for test purposes, four central stations[4] were operating a throttle pressure of 550 psi, and one[5] designed for 1200 psi operating pressure was just being placed in service. Several 400-psi and 450-psi industrial plants were being considered and at least five in that pressure range were in process of design or construction, but higher pressures, 500 psi and up, were still a subject of academic discussion so far as industrial applications were concerned.

"High pressure" is a relative term and for the purpose of this paper it is defined as not less than 500 psi at the prime-mover throttle. Under this definition, the first high-pressure industrial power plant[6] went into operation in 1927, although another manufacturer[7] had installed a 1250-psi boiler for purely process work in 1926. No high-pressure industrial plants were reported in 1928, and not more than 12 were in operation at the end of 1933. Later development has been more rapid, but published records and other sources of information disclose only 85 plants now operating in the United States supplying power *and* steam to industries, in which the throttle pressure is 500 psi or higher. This number includes six installations owned and operated by public utilities. The data on which this survey is based are drawn from these 85 plants and while no claim is made for completeness, it is believed that practically all of the major installations are included. The 85 plants have a combined power-generating capacity of 1,166,875 kw, a total steam-generating capacity of 30,785,300 lb per hr, and represent a probable investment of at least $125,000,000. A number of additional plants are now under construction and it is expected that by the end of this year there will be nearly 100 plants in operation with a combined capacity of approximately 1,350,000 kw. These totals do not include the plants, at least 40 in number, where high-pressure boilers are installed to supply steam for process use only, for testing equipment, or for future power generation, nor do they include the plants in which the boilers are designed for 500 to 600 psi, but which actually supply steam to prime movers at 425 to 475 psi.

The foregoing figures include the River Rouge power plant of the Ford Motor Company, which contains one 15,000-kw back-pressure turbine generator supplying steam to the manufacturing plant, and three 110,000-kw high-pressure condensing units which differ in no way from typical central-station machines. In subsequent analyses, these three condensing units are excluded from the totals in order to prevent distortion of the averages. On this basis, the combined capacity of the 85 plants is 836,875 kw, of which 284,000 kw is operated by public utilities and 552,875 kw by manufacturing concerns.

PRESSURES

Excluding the condensing units at River Rouge the 85 plants contain 134 turbine generators and two reciprocating-engine generators. Of the 136 prime movers, 108 operate at throttle pressures between 500 psi and 750 psi, but more than 25 per cent of the installed capacity operates at pressures above 1200 psi. Table 1 shows the number and capacity of units for various pressure ranges.

TABLE 1

Throttle pressure, psi	No. of prime movers	Combined capacity, kw
500–599	21	78,525
600–749	87	439,400
750–899	14	86,500
900–1199	0	0
1200–1600	11	209,450
Over 1600	3	23,000
	136	836,875

There is no "trend" of pressure with respect to time. The highest-pressure installation[8] included in this group started operation in 1939, but the only other plant[9] operating at a pressure above 1600 psi dates from 1931. The majority of plants in the 1200- to 1600-psi class have been completed since 1935, and five of the ten plants in this pressure range are operated by public utilities. Pressure is not a function of ownership, however, because the largest utility plant[10] in the group operates at a throttle pressure of only 600 psi, and the two highest-pressure plants, just mentioned, are owned and operated by manufacturing concerns.

No generalizations can be made about the "best" or the "ideal" pressure for plants supplying industrial steam. For condensing turbines in utility plants, it may well be argued that in localities affording moderately priced fuel and abundant circulating water, there is no profit in throttle pressures above 900

[1] Fellow A.S.M.E.

[2] "The Value of Higher Steam Pressures in the Industrial Plant," by W. F. Ryan, Trans. A.S.M.E., vol. 47, 1925, p. 779.

[3] Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

[4] Philo (initial operation, October, 1924); Twin Branch (April, 1925); Crawford Avenue (May, 1925); and Columbia (November, 1925).

[5] Edgar (initial operation under load of 1200-psi unit, December, 1925).

[6] The Solvay Process Company, Syracuse, N. Y.

[7] Masonite Corporation, Laurel, Miss.

* All pressures are gage unless otherwise stated.

Contributed by the Power Division and presented at the Spring Meeting, Worcester, Mass., May 1–3, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[8] Diamond Alkali Company, Painesville, Ohio; throttle pressure 2000 psi.

[9] The Philip Carey Mfg. Co., Lockland, Ohio; throttle pressure 1650 psi.

[10] Louisiana Station, Gulf States Utilities Co., Baton Rouge, La.

psi.[11] In the industrial plant, however, it may be economical to use the highest pressures commercially available if the electric power demand is high in proportion to the steam required for process, and if load factor and other conditions are favorable.

In many industrial-plant designs, the question of pressure has been approached from the wrong angle. In order to generate more by-product power in a given situation, process pressures have been limited or even reduced when greater over-all savings might have been made by exactly the opposite procedure.[12] In some heat applications, particularly evaporative processes, high saturated-steam temperature is quite as valuable as it is for power generation. One instance is recorded where changing the process pressure from 10 psi to 150 psi reduced the steam consumption approximately 50 per cent. This, of course, was a blow to by-product power generation in that plant, since the prime movers must operate on half the throttle flow and exhaust against a 500 per cent increase in the absolute back pressure. The same quantity of by-product power could not be generated under the new conditions even with a throttle pressure of 3000 psi, but the fuel savings from reduced steam consumption were of such magnitude that a large net saving in production expense would remain if all of the power were purchased or generated by condensing units.

In another plant, substitution of 800-psi steam for direct firing to heat process materials effected a gross saving of more than $40,000 per year.

The use of high pressures for process work is a field in which some industries may make savings greater than any that are conceivable in connection with power generation. For the ultimate development of high pressures in industrial work, steam utilization and power generation must be treated as a joint problem, the objective being to secure the lowest over-all manufacturing costs, rather than the lowest cost or highest yield of electric power.

TEMPERATURE

Table 2 shows the number of units and capacity included in different ranges of throttle temperature.

TABLE 2

Throttle temp, F	Number units	Combined capacity, kw
Under 600	1	10,000
600–649	6	12,250
650–699	8	31,000
700–749	57	310,775
750–799	47	211,100
800–849	9	71,000
850–899	0	0
900 and over	8	190,750
	136	836,875

More than half of the units having 42 per cent of the total capacity operate at temperatures below 750 F. In 1925, the generally accepted maximum practical temperature was 750 F, and in the aforementioned paper[2] written at that time the author made the perhaps naive statement that in considering how high a pressure should be used for noncondensing prime movers "it is almost axiomatic that the operating temperature should be as high as the materials of construction permit." Apparently it has seemed axiomatic to few others, and in general, the tendency has been to use the lowest temperature that would give the required quality of exhaust steam. Nevertheless, the author believes that the problem of temperature in industrial power applications has not been correctly approached in many cases, and that some of the existing installations might have achieved equal results at less cost by using lower pressure and higher temperature.

The effect of throttle temperature on the water rate of back-pressure turbines is sufficiently well understood. For example, with 100 psi back pressure, as much by-product power per unit of process steam can be generated with 550 psi and 750 F at the throttle as with 700 psi and 675 F. The lower-pressure, higher-temperature steam, however, has a higher enthalpy, and it has been incorrectly assumed that a plant designed for those conditions would necessarily consume more fuel per unit of output. Also, the exhaust from the prime mover would be highly superheated and in many processes superheat is of no value. However, if a thoroughfare desuperheating heater is installed in the exhaust to remove the surplus superheat and transmit it to the boiler feedwater, the fuel consumptions for the two steam conditions would be identical, but the lower-pressure installation should show an appreciably lower capital cost, and slightly lower expense for auxiliary power, maintenance, and perhaps for feedwater treatment.

In a recent paper[13] which should be thoroughly digested by every engineer contemplating the design of an industrial power plant, it is shown that the yield of by-product power per 1000 lb of process steam may be increased more than 35 per cent by raising the throttle temperature of a 650-psi high-back-pressure turbine from 600 F to 850 F, and installing a thoroughfare desuperheating heater in the exhaust. This is accomplished with no increase in throttle flow and no increase of fuel consumption except to supply the 5000 ± Btu per kwhr required for the generation of the additional power. This represents an advantage from high temperature in industrial applications materially greater than can be obtained in central-station service.

The analysis of this problem is one which justifies a paper in itself, and no attempt will be made to reach conclusions here, but the point to be emphasized is that the selection of steam temperature for the industrial plant is a problem peculiar to that type of power generation, and central-station practice has no more significance with respect to temperature than it has with respect to pressure. In designing an industrial power plant, temperature is not a secondary problem to be considered after the pressure has been determined, but a primary problem which may have a major effect on over-all results. Temperature and pressure should be worked out together with full consideration of the effects of each on investment and operating costs.

REHEAT

All of the high-pressure utility plants operating or under construction in 1925 provided reheating of steam at some stage of expansion through the prime movers, using secondary superheaters located in the gas stream of one or more of the main boilers. So far as the author is aware, this practice has never been followed in an American industrial plant, but steam reheating has been used for two installations; these are the first 1200-psi unit at River Rouge, which is not included in this survey, and the reciprocating-engine installation at Lockland, Ohio. In the latter, steam is supplied to the throttles at 1650 psi and 810 F and passes through a live-steam reheater between the intermediate- and low-pressure cylinders. Originally, automatic regulation was provided, designed to maintain about 10 F superheat in the final exhaust from the engines. The reason for this arrangement has never been disclosed by the German designers, but thermodynamic analysis shows that an effective

[11] "Why Exceed 1000 Lb per Sq In.," by A. L. Mellanby, *Power and Works Engineer*, vol. 33, no. 379, January, 1938, pp. 5–7.

[12] See discussion by Z. G. Deutsch, Trans. A.S.M.E., vol. 53, 1931, paper FSP-53-26a, p. 350.

[13] "An Improved System in the Application of Noncondensing or Extraction Turbines," by H. W. Cross and E. S. Wells, Jr., Trans. A.S.M.E., vol. 62, no. 1, January, 1940, p. 37.

separator at this point would have given a better plant economy than the reheater. In present operation the reheat is used only to the extent necessary to prevent pounding in the low-pressure cylinder.

As previously stated, many industrial plants could make efficient use of the highest practicable throttle temperatures, but few, if any, could show a gain from reheating which would be commensurate with the cost and complication involved unless pressures approaching the critical pressure are eventually used in industrial plants.

PRIME-MOVER CHARACTERISTICS

Seventy-three per cent of the units included in this survey are back-pressure machines. The remaining 27 per cent, having 38 per cent of the total capacity, are equipped with condensers; these condensers are usually small, in some instances designed for less than 15 per cent of the maximum throttle flow.

Table 3 shows the number and capacity of units for various ranges of back pressure.

TABLE 3

Back pressure, psi	Number units	Total capacity, kw
Vacuum	37	317,750
Atmospheric to 15	7	22,500
16 to 25	4	18,000
26 to 50	9	43,000
51 to 100	6	25,000
101 to 200	64	340,425
Over 200	9	70,200
	136	836,875

Of the condensing machines, only one 500-kw unit[14] is nonextraction. The latter, however, operates in parallel with a larger machine exhausting at 40 psi and the two units in this plant are, therefore, the equivalent of a condensing extraction machine. One large unit now under construction,[15] which may operate at a pressure of 500 psi or more, is a straight condensing machine with extraction only for feedwater heating.

Extraction pressures range from 5 psi to 400 psi; 38 turbines are arranged for single extraction, 15 for extraction at two pressures, and one is a mixed-pressure dual-extraction machine. The available information does not disclose any machines with more than two fixed-pressure extraction connections, or any back-pressure machines which have two. In some plants, however, high-back-pressure units top lower-pressure extraction machines not included in the scope of this survey, and some high-pressure machines in the same plant are designed for extraction or exhaust at different pressures so that by-product power is generated at several different levels. In one plant at least seven process pressures are provided by exhaust or extraction from different prime movers, the pressures ranging from a few inches of vacuum to 400 psi.

STEAM-GENERATING EQUIPMENT

The adoption of high pressures was accompanied by a simultaneous revolution in boiler design. For the earliest installation included in this survey, the boilers were designed to produce 22.5 lb of steam per square foot of boiler heating surface per hr, including the water-cooled furnace. The average heat input to the boiler, furnace walls, and economizer combined was 11,500 Btu per sq ft per hr. These steam generators were installed in what was then one of the largest and most efficient industrial boiler plants in the country. In the old plant the maximum steam output was 4.15 lb per sq ft of boiler surface per hr, and the average heat input was 3100 Btu per sq ft of total surface per hr, including the economizers. Obviously, the new steam-generating equipment presented operating problems which had no relation to pressure, in spite of the fact that only condensate was used for feedwater.

Many of the high-pressure installations designed between 1928 and 1933 followed the more conservative design of earlier low-pressure boilers but all of the more recent installations for which data are available have rates of heat transfer which would have been considered excessive 15 years ago, although they are lower than current central-station practice. Sixteen recently installed industrial boilers, operating at 600 psi to 850 psi pressure and ranging in capacity from 65,000 to 500,000 lb per hr show a weighted average heat input of 9200 Btu per sq ft of total surface per hr, including boilers, waterwalls, and economizers. The corresponding figure is 16,000 Btu per sq ft per hr for six utility-plant boilers, operating in the same pressure range, with individual capacities of 140,000 to 575,000 lb per hr, but with the same total capacity as the sixteen industrial boilers. The lower average rate of heat input for the industrial boilers is due chiefly to the general use of treated water for boiler feed, and the higher concentration of solids in the circulating system.

Except for a greater liberality of heating surface, steam-generating equipment, including auxiliaries, fuels, and firing methods, shows no marked difference from current central-station practice.

RECIPROCATING ENGINES

In 1925 there was some reason for expecting that many of the smaller high-pressure industrial power developments might utilize reciprocating engines for prime movers. This expectation has not been realized due principally to the present high efficiency and reliability of back-pressure turbines, even in relatively small sizes. The aforementioned engine generator installation at Lockland, Ohio, has been in successful operation for several years, using steam at 1650 psi and 810 F, and there is no mechanical reason why steam engines could not be used with very high steam pressure and temperature. However, the water rate of these engines is no better than the water rate of a present-day noncondensing turbine of the same size and the radiation losses are appreciably higher; also more frequent and more extensive outages are required for inspection and maintenance. No 500-psi or higher engine drives have been used for variable-speed equipment, such as compressors and pumps, although for this service the engine has a materially lower water rate than the turbine at partial loads and reduced speeds. Several thousand horsepower of engine drives have been installed, operating at pressures up to 450 psi and temperatures up to 750 F, but all of these installations were made before 1932 and there has been no recent progress in this direction.

BOILER FEEDWATER

It was recognized in 1925 that the boiler feedwater supply would be a serious problem in high-pressure industrial plants on account of the large percentage of make-up usually required. Tremendous progress has been made in the art of boiler feedwater purification, but it is still the major problem for high-pressure industrial work where condensate is not returned from the process. The claim is made that any natural fresh water can be chemically treated for any boiler conditions. While this statement may be technically true, its realization may require large expenditures for equipment and always requires an advanced operating technique to maintain satisfactory results when poor water is treated for high pressures.

The highest-pressure boiler in the group is fed with treated water, but ten of the twelve plants operating at pressures above 1200 psi use condensate exclusively. The energy loss which

[14] National Vulcanized Fibre Co., Yorklyn, Del.
[15] Carnegie-Illinois Steel Corp., Rankin, Pa., 35,000 kw.

results from the use of evaporative condensers is less than is commonly supposed, and the cost of evaporators is partly offset by savings in cost of steam-generating equipment, due to the possibility of using less heating surface and smaller drums, when pure feedwater can be assured.

RESERVE CAPACITY

One of the outstanding features of recent industrial-plant design is the willingness of the owners to rest factory production wholly or partially on a single boiler or turbine unit. For low-pressure plants of the type prevalent in 1925, it was axiomatic that there must be a sufficient number of boilers so that one could be out of service for inspection or repairs at any time without curtailing production. There are relatively few of the modern high-pressure installations where this reserve capacity has been provided, but as will be shown later, the results have been reasonably satisfactory.

Of the 85 plants included in this survey, 29 have a single high-pressure boiler. In some cases, older low-pressure boilers relay the high-pressure equipment, but in others, factory production must be curtailed during outages. Some confusion arises in comparing costs of generated and purchased power when this absence of relay capacity is not taken into consideration. The ability of some industries to operate satisfactorily without relay capacity has stimulated an interest on the part of public utilities in designing competitive rates based on interruptible service, which is the only type of service strictly comparable with that provided by the majority of the plants in this group.

OPERATING RESULTS

In the discussion, 15 years ago, pessimism was frankly expressed regarding the ability of industrial operating personnel to handle high-pressure equipment. Experience has proved these fears unfounded, and such difficulties as have arisen have been with equipment, water, and fuel rather than with men.

A few installations have been disappointing with respect to yield of by-product power and over-all costs, and several have failed to develop the design capacity, but the majority have shown high thermal efficiency and high availability when operated within their actual capacity. The term "actual capacity" is used in contradistinction to the design capacity or manufacturers' ratings. In Table 4 the composite results for six plants indicate the availability and efficiency obtainable in well-designed, competently operated plants.

The plants included in Table 4 are not hand-picked to show favorable results, but include all of the plants for which the author had sufficient information to compute availability factors and efficiency. It will be noted that the availability of boilers and prime movers is not far different from the corresponding figures published by the Edison Electric Institute for high-pressure utility plants. Oddly enough the general average is lowered appreciably by the one plant which has reserve capacity, and in which plenty of time was available for inspection and repairs.

TABLE 4

Total installed capacity	
Boilers, lb per hr	2,535,000
Generators, kw (name-plate rating)	77,500
Total number of prime movers	13
Total number of boilers	14
Total generation for 12 months	
Steam, lb	14,836,966,000
Power, kwhr	458,275,250
Total of individual maximum demands	
Steam, lb per hr	2,294,000
Steam, per cent rated capacity	91
Power, kw	76,970
Power, per cent rated capacity	99
Load and capacity factors	
Ratio, average output to maximum demand	
Steam	74
Power	68
Ratio, average output to rated capacity	
Steam	67
Power	68
Availability	
Total outage, all prime movers, hr	12,807
Average outage per unit, hr	986
Average availability of prime movers, per cent	89
Total outage, all boilers, hr	16,329
Average outage per boiler, hr	1,166
Average boiler availability, per cent	87
Over-all thermal efficiency	
Total net output as power, kwhr	379,429,000
Heat equivalent of net power output, million Btu	1,296,000
Total net output as process steam, lb	11,758,644,000
Heat equivalent of net steam output above heat in returns and make-up water, million Btu	11,160,000
Total net output, million Btu	12,456,000
Total fuel consumption, million Btu	16,426,000
Over-all thermal efficiency, per cent	76
Average heat consumption for power generation only, Btu per net kwhr	4,780
Yield of by-product power	
Gross kwhr per thousand lb steam generated	31
Net kwhr per thousand lb steam delivered	32

INSTALLATION COSTS

Construction costs vary widely and the cost of any single installation has little significance because of the extreme differences in conditions. In many cases the new equipment is installed in existing buildings or on sites where existing coal-handling facilities and water supplies can be utilized with a considerable saving in first cost. The following composite costs, however, for 13 back-pressure installations may be of interest. These plants range in capacity from 2000 kw to nearly 100,000 kw, and all are designed for throttle pressures between 600 psi and 850 psi. The costs include all of the equipment installed, together with such building alterations or extensions as the individual jobs required, and in several instances complete new buildings.

Total steam-generating capacity, lb per hr	5,885,000
Total electric-generating capacity, kw	186,900
Total cost	$22,832,000

The weighted average of costs is approximately $2 per lb per hr of steam-generating capacity plus $60 per kw of electric-generating capacity. This formula, however, applied to any individual installation, may be in error by as much as 35 per cent, and the fact that some were built during low-construction-cost periods makes them unreliable for present-day use. Steam-generating capacity should not be confused with net delivery to process mains, and it should be remembered that the large ratio of steam generation to power output results in an auxiliary power consumption which appears high when compared with central stations. On a net-output basis, the average cost for the foregoing plants would be approximately $2.50 per lb of steam per hour plus $72 per kw. For individual plants the steam factor ranges from $1.48 to $3.57 per lb and the electric factor from $38 to $123 per net kw.

The average excess cost of the complete plants over the estimated cost of plants designed to deliver the same quantities of low-pressure process steam only is about $105 per net kw, a figure which is less than the estimates made 15 years ago, largely because greater economy of boiler design has offset higher costs of labor and material. None of the plants included in this

composite cost has any relay capacity, either steam or electric, and this fact should not be overlooked in a consideration of the costs.

PRODUCTION EXPENSE

Available figures on production expense are even more unsatisfactory for comparative purposes than the installation cost data, due to variations in operating conditions and bookkeeping methods. The best statement which the author is able to make, based on the limited data available, is that in moderate-sized plants operating at a good load factor the production cost of 1000 lb of steam and 30 kwhr from fuel, costing 15 cents per million Btu, ranges from 29 cents to nearly 40 cents. This is bare operating expense, exclusive of depreciation, taxes, or interest on investment, and the units are net deliveries to manufacturing departments, not gross generation.

How these costs are divided between steam and power is a matter of bookkeeper's choice. If power generation is charged only with the reduction of enthalpy of the steam as it passes through the prime movers, it results in what appear to be very low power costs, and the author has seen figures recorded as low as 1.1 mills per kwhr. If power generation is charged with the available energy extracted from the steam, the computed cost will be very much higher, and the author has seen unit power costs of approximately 2 mills and approximately 8 mills computed by different cost systems from substantially the same over-all costs of steam and power. Division of costs between steam and power is also a question which merits a paper, if not a symposium, with a view to some standardization of bookkeeping methods.

SUMMARY

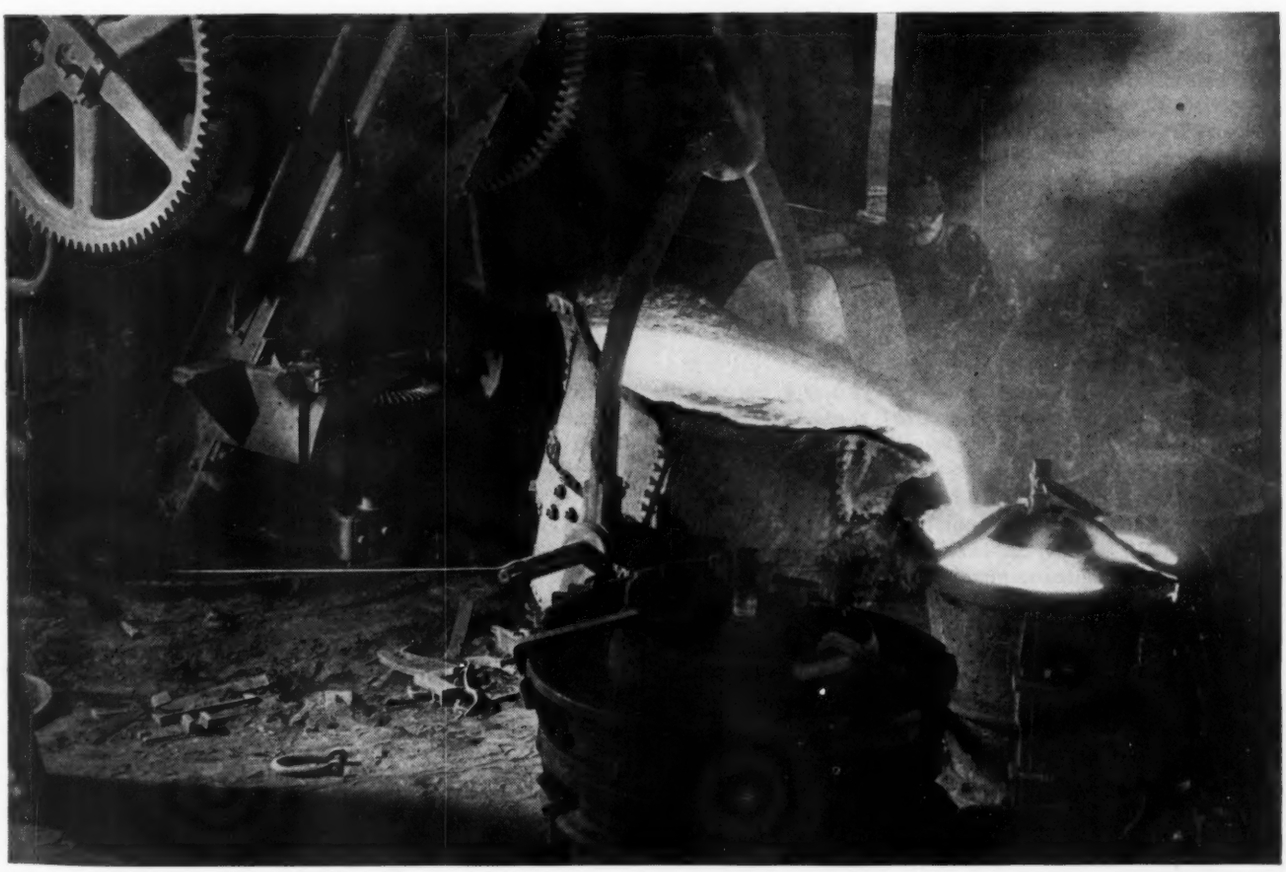
High-pressure industrial power plants, by the limited definition of this paper, are not numerous and their combined capacity is a very small fraction of the total generating facilities in the United States.

The industries have not hesitated to use the highest pressures available for power generation, but have been somewhat indifferent to the advantages of high pressure for process use. In general, temperatures used have been lower than conditions might justify.

Development of the high-pressure reciprocating engine for power generation has been negligible but turbines have reached a high peak of efficiency and adaptability to process requirements.

The general use of treated feedwater requires a boiler design with more heating surface than is currently used in central-station service. Improved technique in feedwater treatment is the outstanding development in this field, but water is still the major problem in the operation of high-pressure industrial plants.

Efficiencies and availability factors are high in well-designed plants. The ability to generate power with a heat consumption of less than 5000 Btu per kwhr with a plant cost—over the cost of a low-pressure steam plant—of little more than $100 per net kw is proof of the economy of such plants when load factor, synchronism of power and steam demands, and other factors are favorable. The absence of reserve or relay capacity in the typical industrial plant should not be overlooked in making comparisons with earlier practice or with use of purchased power.



POURING MOLTEN CAST IRON INTO COMPLETED MOLD

(Photograph taken by Howard A. Hoffer and shown at the Fourth Annual Photographic Exhibit held during the 1939 A.S.M.E. Annual Meeting in Philadelphia, Pa.)

Effect of COAL CHARACTERISTICS *on* PULVERIZED-COAL FIRING

By OLLISON CRAIG

RILEY STOKER CORP., WORCESTER, MASS

COAL is burned in a furnace for the purpose of generating heat which, in turn, is to be transmitted to heat-absorbing surfaces for the purpose of generating steam. While steam generation is the primary purpose, it is also desirable that the generation be as efficient as may be economical, that the equipment be kept in service as continuously as possible, and that the operation be trouble-free. When coal is burned in pulverized form in a furnace, that portion of over-all boiler efficiency for which combustion is responsible is high when carbon loss is kept at a minimum, when the CO_2 or excess air is maintained within predetermined limits, and when combustion as defined by this carbon loss and this excess air is completed, within the limits of the furnace volume. Continuous and trouble-free operation is had if ignition is maintained constant and steady and if molten ash in the form of slag does not accumulate in any portion of the furnace or on boiler heating surfaces to an extent interfering with efficient operation.

Carbon loss, excess air, and slag are affected by the characteristics of coal being burned, the design of the furnace, the design of the burners, and the characteristics of the pulverizers.

It is the purpose of this paper to discuss how coal characteristics can affect carbon loss, excess air, and slag, rather than to discuss furnace design, burner design, or characteristics of pulverizers. However, all these factors are so interrelated that it becomes necessary to touch at least briefly on them in discussing the effect of coal characteristics. Characteristics affecting the burning of coal in pulverized form and the results which are obtained from pulverized-coal firing are: volatile matter, fixed carbon, agglutination, swelling, ash, ash-fusion temperature, moisture, sulphur, and grindability.

VOLATILE MATTER AND FIXED CARBON

Bituminous coals, in general, vary from 15 to 40 per cent in volatile matter. Coals containing less than 22 per cent volatile matter are classed as low-volatile. Coals containing from 22 to 31 per cent volatile matter are classed as medium-volatile. Coals containing more than 31 per cent volatile matter are classed as high-volatile. When high-volatile coal is burned in pulverized form, volatile gas is first distilled and burned, leaving fixed carbon for final combustion. Such coal will burn out more quickly and more completely than would be the case with low-volatile coal, provided all other conditions are the same. If a high-volatile coal, containing 30 per cent volatile on a moisture- and ash-free basis, is burned, then for each pound of combustible matter introduced into the furnace, there is 0.3 lb of volatile gas produced and 0.7 lb of fixed carbon remaining. If a coal, containing 20 per cent volatile matter on a moisture- and ash-free basis, is burned, there is then 0.2 lb of volatile gas released for each pound of combustible and 0.8 lb of fixed carbon remaining. Since volatile gas distills and oxidizes quite rapidly, the length of time to complete combustion to the point where there is a predetermined amount of unconsumed carbon remaining in the ash is less in the case of high-volatile coal than in the case of low-volatile coal, since there is a less amount of the slow-burning fixed carbon. The effect of a greater amount of volatile matter in coal on the determination of furnace volume or, conversely, heat release per cubic foot, is to require a smaller furnace volume, provided the size of the furnace is not dictated by other considerations. If furnace volume is established, then the loss due to unburned carbon in ash will be less with high-volatile than with low-volatile coal, assuming the coal to be ground to the same fineness and all other conditions constant. High-volatile coal, then, has an advantage in regard to time necessary for completion of combustion.

Quick ignition and stability of ignition are of much importance in pulverized-coal firing. The more quickly ignition can take place, the less time will be required for completion of combustion within the confines of the furnace and the less will be the carbon loss. Stability of ignition and maintenance of flame are necessary for the prevention of explosive puffs in a furnace. Ignition and stability of ignition are dependent on velocity of flame propagation in a mixture of pulverized coal and air, on the temperature at which heat may be radiated to the incoming mixture, and on the temperature in the region through which the mixture passes before leaving the furnace.

Pulverized high-volatile coal, when mixed in suspension with air and ignited, has a higher velocity of flame propagation than is the case with low-volatile pulverized coal. High-volatile pulverized coal which is low in ash and which is mixed with the proper amount of air, may have a flame-propagation velocity as high as 2800 fpm. With low-volatile pulverized coal this velocity may be less than 1000 fpm. If the velocity of flame propagation of a coal and air mixture being introduced into a furnace is low, then the velocity of discharge of this mixture and the velocity of the secondary air which may be admitted at the burner must also be low to permit ignition and to prevent extinguishing the flame, which may occur in about the same manner that a match can be blown out. Coal mixtures in which the velocity of flame propagation is high ignite more quickly and produce a flame which is much more stable. A wider range of operation can be had with mixtures having higher velocities of flame propagation since ignition can be maintained over a wider range of velocities of discharge from the burner.

Quicker ignition and better flame stability are obtained with high-volatile coal for another reason. A mixture of coal and air must be heated to the temperature at which the coal will ignite. This requires a source which can supply heat to the incoming coal and air. More volatile gases are distilled from high-volatile coal and produce a zone of higher temperature in the region near the burner from which heat can be radiated to the incoming fuel and air. This gas flame is then the source of heat igniting the incoming coal.

Present-day practice is to design furnaces which are almost completely lined inside with water-cooled metal surfaces. The average temperature in such furnaces is obviously lower than it is in all-refractory furnaces. Experience has indicated that if

Contributed by the Fuels Division and presented at the Spring Meeting, Worcester, Mass., May 1–3, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

pulverized coal, either high-volatile or low-volatile, is burned at a given rate in an all-refractory furnace, the loss due to unburned carbon is less than it would be if the same coal were burned at the same rate in either a partially or completely water-cooled furnace. This fact would indicate that water-cooled surfaces in a furnace tend to retard combustion of fixed carbon. It might be considered that this could be compensated for by burning coal at a greater rate in a water-cooled furnace and thereby raise the average furnace temperature. However, this does not accomplish the purpose, since with an increased rate of coal burning, a particle of coal is in the furnace for a shorter time and as a result the fixed carbon is less completely burned. Other means can be taken partially to compensate for the cooling effect of water-cooled furnaces. Coal and air can be introduced by means of multiple burners in such a way as to produce more turbulence in the furnace. The scavenging action resulting from increased turbulence will result in more complete combustion of fixed carbon and will, thereby, at least partially compensate for the slower burning effect produced by lower furnace temperature. Here again, high-volatile coal has an advantage since it is not so greatly affected by the cooling action of a water-cooled furnace as is low-volatile coal. Again, experience shows that if a high-volatile coal is burned in a water-cooled furnace at a given rate, the loss due to unburned carbon is less than when burning low-volatile coal in the same furnace at the same rate.

The difference is so pronounced that it frequently becomes necessary to make corrective modifications in the case of water-cooled furnaces when low-volatile coal is burned. One method of accomplishing this is to reduce the rate at which heat is absorbed by water-cooling surfaces in the furnace. This may be done in the original design by the application of heat-retarding blocks or refractory material to the surface of furnace water tubes, or it may be done later, after experience with operation has indicated the necessity, by the application of refractory material over the surface of the water tubes, this refractory material being applied on those areas of the furnace walls on which it may be the most effective. These areas are usually in line with the burners on the side walls and in some cases on the rear wall and extend a few feet above and below the center line of the burners.

The effect of the application of such heat-retarding material is most strikingly illustrated in the case of burning petroleum coke. Petroleum coke usually has less volatile matter than does even low-volatile coal. The volatile matter of petroleum coke may be from $7\frac{1}{2}$ to 20 per cent and is usually below 15 per cent. It is almost impossible to ignite and maintain a stable flame with this material in an entirely water-cooled furnace. Recently, an oil refinery started burning pulverized petroleum coke in furnaces of existing boilers. The furnaces were originally built for oil firing and later were modified for firing pulverized midwestern coal by the application of waterwalls to the side walls and rear walls. These furnaces had less cooling than they would have had if they had been designed for use with pulverized midwestern coal. When pulverized petroleum coke was first burned in these furnaces, the fly-ash loading of gases leaving the boilers was excessive and the carbon content of this fly ash was quite high. A 10-ft belt of refractory was placed on each side wall, the center of this belt being in line with the center line of the horizontal burners. Later a 10-ft belt was placed on the rear wall. With this refractory on the side walls and rear wall, half the waterwall area in each furnace was covered with refractory extending $2\frac{1}{2}$ in. beyond the surface of the tubes. Before refractory was applied, fly-ash loading in stack gases at about 400 F was from 3 to 6 grains per cu ft and the carbon content of this fly ash was from 96 to 97 per cent. With refractory on the side walls, fly-ash loading in the gases was reduced to 1.25 to 1.5 grains per cu ft, and the carbon content to a range of 88 to 92 per cent. With refractory on three walls, the fly-ash loading dropped to 0.3 grain per cu ft and the carbon content to a range of 70 to 75 per cent. The carbon content in the fly ash is apparently high, but the original coke contained only 0.7 per cent ash. This experience illustrates in possibly exaggerated form the necessity for compensating for low-volatile content of pulverized coal.

Practical considerations dictate the necessity of constructing pulverized-coal furnaces with surrounding walls which are composed almost completely of water tubes. With such furnaces, high-volatile coal has an advantage as compared to low-volatile coal, in initial ignition, stability of flame, and carbon loss. This requires that in such furnaces, where low-volatile coals are to be burned, something be done in order that the low-volatile coal can be burned with the same effectiveness as high-volatile coal. This usually means the application of heat-retarding material to the water-cooled surfaces. In some cases this can be sufficiently accomplished by the accumulation of ash on the surfaces of furnace wall tubes. In other cases, it becomes necessary to apply refractory or some form of blocks.

In the design of a new boiler unit it is well to consider whether high- or low-volatile coal will be burned, the range of load and the provisions required in furnace-wall design so that the selected coal may be burned with the best results.

AGGLUTINATION—SWELLING—ASH

Certain kinds of coals have a tendency to cake. These are called "caking coals" and this caking property is called "agglutination." When such coals are burned on grates or on a stoker, the effect of this property is to produce a fuel-bed condition in which coal particles and lumps adhere to each other in such a way as to be largely impervious to the passage of air. Some form of agitation is necessary to break up these cakes of fuel in order that air can have access to the surfaces of coal particles. Similar adherence of particles occurs when this same kind of coal is fired in pulverized form. A large number of separate and individual particles, which have been reduced to an extremely fine state in a pulverizer, can, when subjected to heat in the furnace, collect and adhere together so as to form an individual mass. The effect of agglutination, when coal is fired in pulverized form, is to increase the loss due to unconsumed carbon, because these accumulated masses cannot become as completely burned passing through furnace as smaller individual particles.

Certain bituminous coals swell or increase in volume when subjected to heat. If such a coal is pulverized and introduced into a hot furnace, each coal particle swells. Since each particle increases in volume with no increase in weight, it is carried more rapidly by the gas stream and is in the furnace a shorter time. The result is increased carbon loss.

The amount of ash in coal will vary from 5 per cent in some eastern low-volatile coals to 20 per cent in some low-grade midwestern coals. The effect of a greater amount of ash in pulverized coal is to reduce flame velocity in a mixture of coal and air and, as a result, to interfere with ignition and flame stability.

The minimum rate at which high-ash coal can be burned in a furnace with continuous firing is greater than with a coal having a less amount of ash but the same volatile.

Experience seems to indicate that it is possible to operate with as low percentage of excess air with a high-ash midwestern coal as with low-ash eastern coal and also that with this same percentage of excess air, the total loss due to unburned carbon is about the same. In order that the total loss due to unburned carbon be about the same with the high-ash midwestern coal, it is necessary that the percentage of carbon in ash and refuse be less than in the case of low-ash eastern coal. This is apparently true because larger furnaces

are provided for a given rate of coal burning when the coal contains high percentage of ash with a low temperature of fusion and because midwestern high-ash coal is usually more free-burning and the fixed carbon is burned more rapidly.

ASH-FUSION TEMPERATURE—MOISTURE—SULPHUR

Coal ash will fuse at temperatures from 1800 F in the case of midwestern coals to 2800 F in the case of good-grade eastern coals. Softened or molten ash will adhere to furnace surfaces, furnace outlets, and heating surfaces of boiler and superheater.

Fused ash which deposits in the furnace causes increased refractory maintenance and interferes with ash disposal. Fused ash which deposits on boiler and superheater surfaces reduces heat absorption and closes off gas passes, in some cases to such an extent as to require the boiler to be taken out of service.

If sufficient water-tube surface is exposed to radiation from the furnace, fine ash particles may be reduced to less than fusion temperature before entering the tube bank. If, in addition, such refractory surfaces as may be in the furnace and also the ash outlet from the furnace are kept a sufficient distance from the flame, no trouble will be experienced by slag accumulation on furnace walls or by slag blocking the ash outlet.

Average furnace temperature can be reduced by burning coal with a greater amount of excess air, at the expense of boiler efficiency. This is frequently resorted to when coal must be burned having ash with lower fusion temperature than was contemplated when the furnace was designed.

The high moisture content of coal affects the performance of a pulverizer; it tends to reduce capacity and fineness of pulverization, and it increases the power required. The immediate effect of moisture in pulverized coal after it is introduced into a furnace is to interfere with ignition. Coal particles must receive sufficient heat to be brought up to ignition temperature. If there is water in the coal particles, this water must first be evaporated. This means that more heat must be received by a coal particle to bring it to ignition temperature. After the water has been evaporated, the vapor then probably acts as a diluent to the volatile gases and retards combustion in much the same way that ash does. Any water that is contained in pulverized coal carries away from the boiler a certain amount of the heat which it receives in the furnace, and to just that extent reduces the over-all efficiency of the steam-generating unit.

However, it is possible that a certain amount of water in at least certain kinds of coal may so affect the process of combustion as actually to result in an increase in the efficiency of the steam-generating unit. This would have to come about through a reduction in unburned carbon or through an ability to operate with less excess air with the same unburned carbon. Tests have been made which have indicated this to be true with certain midwestern coals. It is well known that with midwestern coals an increase in moisture content will, to a considerable extent, increase over-all efficiency when a boiler is fired by means of an underfeed stoker, and it is also known that this is true when a boiler is fired by a traveling-grate stoker, except that in the case of the traveling-grate stoker there is a lower limit to the maximum moisture content which will produce maximum efficiency. It is also known that it is almost imperative to have more than a normal moisture content with certain caking eastern coals, if these are to be successfully burned on a traveling-grate stoker. The action of moisture in coal which produces these results in the case of stoker firing may or may not be similar to the action which occurs in the case of pulverized-coal firing. It might seem, however, that, at least with certain kinds of coal, there could be some amount of moisture in coal particles which, in the process of evaporation and expansion, could leave the coke particle in such a condition that it would be more capable of combining with oxygen.

The effect of unusual moisture content, however, is to interfere with ignition, and stability of flame, and to cause erratic combustion and increase in carbon loss.

Usually it is not economical to dry coal which is to be pulverized in a direct firing system. If the coal is dried, heat must be supplied for evaporating the moisture in any case. Unless this is supplied from waste heat leaving the boiler, the drying cost may be greater than loss in heat carried from the boiler in the vapor.

The sulphur content of coals varies through a wide range and may be as low as $^1/_2$ per cent and as high as 5 per cent. Sulphur in coal usually occurs in the form of iron pyrites. A large amount of sulphur usually indicates that the ash-fusion temperature is low and trouble will be experienced both from slag resulting from this low ash-fusion temperature and from the effect of the iron combined with the sulphur in iron pyrites.

Grindability is a measure of friability, or the ease or difficulty with which coal can be reduced to a fine state. Coal which has a high grindability is more easily pulverized, and coal which has a low grindability is pulverized with greater difficulty. There are a number of indexes which give a measure of the grindability of various coals. Any index is usually expressed in terms of a numerical value, and 100 on a chosen scale represents a certain grindability which is used as a measure of comparison. A coal which has a grindability of 50 in terms of some index is more difficult to pulverize than a coal which has a grindability of 100. All types of pulverizers will have less capacity with coal of low grindability than wich coal of high grindability. At the same rate of grinding in terms of pounds of coal per hour, and with the same power input, coal of low grindability will be pulverized to a less degree of fineness than will be the case with coal of high grindability. There is a broad relation between volatile matter of bituminous coal and grindability. In general, low-volatile eastern bituminous coals come within the high-grindability range, while high-volatile eastern bituminous coals come in a low-grindability range. Coal having from 15 to 25 per cent of volatile will generally fall within the range of 90 to 100 grindability, while coal having 30 to 35 per cent volatile will generally fall within the range of 50 to 65 grindability. Midwestern coal, with the same percentage of volatile as high-volatile eastern coal, will usually have somewhat higher grindability than eastern coal. It seems fortunate that low-volatile coal does have high grindability since, with the same pulverizing equipment, it can be reduced to a finer size, and a finer size tends to compensate for the effect of lower percentage of fixed carbon. By the same reasoning, it is not necessary to pulverize high-volatile coal to the same degree of fineness as low-volatile coal, since there is less fixed carbon to be burned. In the case of midwestern coal, it is possible to pulverize it with still less degree of fineness, since this coal is "free-burning" or one which has practically no caking tendency and in which the free carbon is apparently so disintegrated and broken up in the process of volatile distillation that there is ready access of oxygen to a greater surface.

All the advantages are not with high-volatile coal in pulverized-coal firing. Low-volatile coal is usually more friable, resulting in a lower purchase price for equipment less power to operate, and less expense for maintaining pulverizing equipment. Low-volatile coals average higher in heat value, so that less weight of coal is required to generate a given amount of steam, and the ash usually fuses at a higher temperature, so that less boiler and furnace maintenance is required and boilers may be kept in operation longer periods of time.

By giving proper consideration to the characteristics of coal or coals most available and most economical to use, designs can be made which will take advantage of those characteristics which may be considered good and which will lessen, or eliminate, the effect of those which may be considered bad.

The CONTROL *of* GASES *in the* WAKE *of* SMOKESTACKS

By R. H. SHERLOCK AND E. A. STALKER

UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH.

IN MARCH, 1934, an investigation was undertaken at the University of Michigan to determine whether or not an addition to the height of the existing stacks would prevent downflow of stack gases into the area surrounding the Crawford Station of the Commonwealth Edison Company, Chicago. This downwash was occasionally observed but the conditions under which it occurred were so varied that the cause and its remedy could not be determined on the basis of existing knowledge. As a result of the information disclosed by the earlier stages of the investigation, the purpose was broadened to include a detailed study of the nature and cause of the behavior of the gas in the wake of the stacks; a study of the effect of the wind velocity, stack-gas velocity, and stack-gas temperature; and a study of devices for controlling the downwash.

An effort was made to establish some relation between downwash and each of the various weather conditions for which the records were sufficiently complete to make an examination possible. Wind velocity, wind direction, barometric pressure, humidity, and seasonal occurrences were studied. Only wind velocity and wind direction showed any consistent relation to downwash.

The investigation was divided into two main parts: One consisted of the adaptation of the mechanics of air flow to this special problem. The other consisted of wind-tunnel tests on models of the station and of individual stacks. Numerous incidental tests were made to exclude the possibility that the true significance of the results was being modified by some detail of the study. All test descriptions and supporting data are omitted here, but they are contained in the final report on the project,[1] and will soon be published in substantially complete form.[2]

THE EFFECT OF WIND STRUCTURE ON DOWNWASH

The smokestacks are cylinders past which the air stream flows and builds up a vortex trail, as shown in a somewhat idealized form in Fig. 1. The top ends of the trailing vortexes occur in the open air near the level of the stack gases. The flow of air into the open ends of the vortex cylinders carries with it gases which are later discharged by the cylinder downstream at a lower level. If this lower level is in the region of the turbulence caused by the station buildings, the gas will be mixed with the turbulent mass of air and part of it will reach the ground.

There also is developed a pair of tip vortexes whose sense of rotation is upward outside of the wake, and inward and downward within the wake. Their influence extends to a considerable distance above the top of the stack and involves high velocities of an inward and downward direction. Even though disintegration at the top of the vertical vortex cylinders should start immediately after they are first formed, the action of the tip vortexes would tend to bring the gases down to a point where they are affected by the flow into the open ends of the vertical vortexes.

The turbulent low-pressure region immediately adjacent to the downstream surface of the stack also is effective in causing downwash. If the gases thus brought down come within the influence of the turbulence over the roof of the building, they will be carried into the turbulent mass behind the building and quickly brought to the ground.

As the wind velocity increases, a vortex with horizontal axis is formed at the upstream edge of the roof. This grows in size and finally flows downstream, leaving after it a vortex layer which separates the lower turbulent mass from the more smoothly flowing upper layers. In effect, the vortex layer is said to form a streamline body within the air. The height of the vortex layer will be different for each station building since it depends not only on the height of the building but also upon its cross-sectional shape and the angle of incidence of the wind. The effect of structures to the windward cannot be ignored. If the top of the stack is lower than the vortex layer, downwash of gases is certain to occur.

Downwash of stack gases occurs in two stages. The first stage is the downflow induced by the eddies in the wake of the stack, and the second stage is the dispersion of the gas within the turbulent mass of air above and behind the station buildings.

The first stage follows fairly definite laws involving wind velocity, stack-gas velocity, and stack-gas temperature, as shown in Fig. 2. The same laws are shown in simplified form

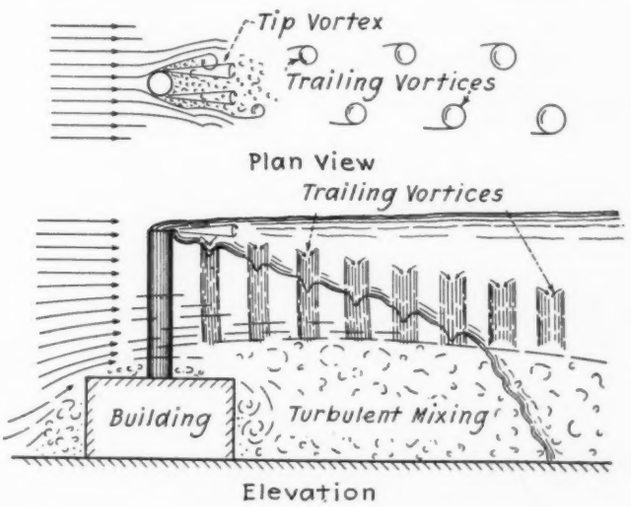


FIG. 1 WAKE OF A SMOKESTACK DURING DOWNWASH OF STACK-GASES

[1] Department of Engineering Research, University of Michigan. Final Report, Project No. 885, for the Commonwealth Edison Company, by Sherlock and Stalker.

[2] "A Study of Flow Phenomena in the Wake of Smokestacks," by R. H. Sherlock and E. A. Stalker, Engineering Research Bulletin No. 29, University of Michigan, Ann Arbor, Mich.

Contributed by the Power Division for presentation at the Semi-Annual Meeting, Milwaukee, Wis., June 17–20, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

in Fig. 3, which was derived from Fig. 2 along the abscissa for one stack diameter.

The second stage of downwash is illustrated in Fig. 4 with the wind blowing across the building model from the north while the stacks were removed, and with gases introduced into the air stream at various heights. The blunt exposure presented by the north wall of the station deflected the turbulent layer to such a height that the gases were brought quickly to the ground from a height equivalent to $1^1/_4$ diameters below the top of the stack.

WIND-TUNNEL TESTS

The experimental work was conducted in the wind tunnel at the University of Michigan, with the tunnel throat reduced to 7 ft between the flat sides of the octagonal cross section, as shown in Fig. 5. Standard methods were used wherever possible but original methods were necessary for the control of the stack-gas velocities and temperatures, for the identification of the gas boundaries in the wake, for the exploration of the tip vortexes, for the determination of the aerodynamic scale relations between the model and its prototype, and for some of the incidental tests. A wooden model of the Crawford Station and surrounding structures was constructed to a scale of 1 to 300. Models of the isolated stacks varied from $^3/_4$ to $3^1/_4$ in. in diameter. An 8-in. cylinder was used for tip-vortex explorations and for the study of the aerodynamic scale relations. Gas temperatures were varied in steps from 70 F to 400 F.

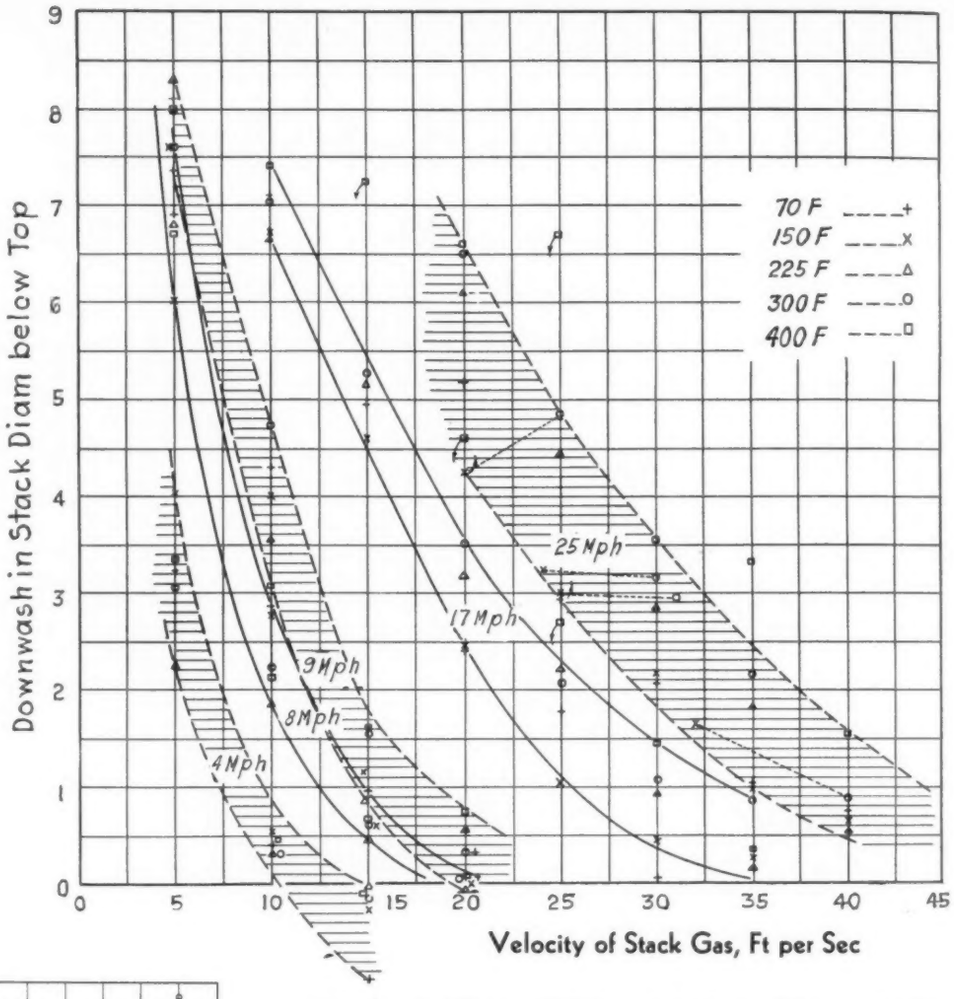


FIG. 2 RELATIONS BETWEEN DOWNWASH, WIND VELOCITY, STACK-GAS VELOCITY, AND STACK-GAS TEMPERATURE

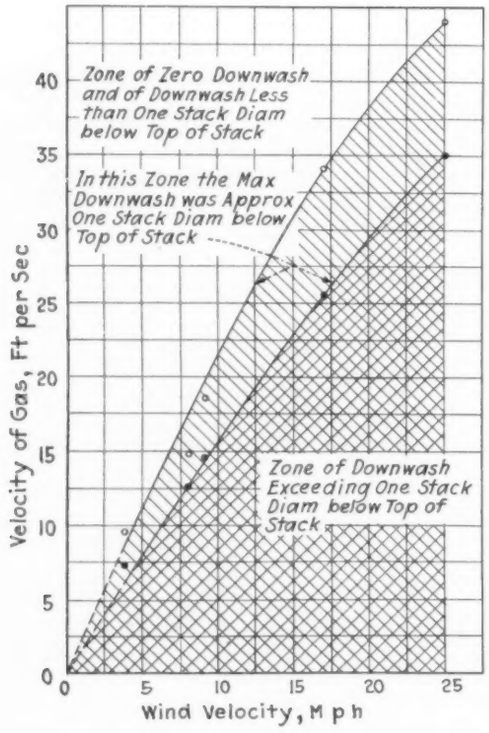

Zone of Zero Downwash and of Downwash Less than One Stack Diam below Top of Stack
In this Zone the Max Downwash was Approx One Stack Diam below Top of Stack
Zone of Downwash Exceeding One Stack Diam below Top of Stack
Velocity of Gas, Ft per Sec
Wind Velocity, M p h

FIG. 3 CRITICAL RELATIONS BETWEEN WIND VELOCITY AND STACK-GAS VELOCITY IN THE CONTROL OF DOWNWASH

The method used for identifying the upper and lower boundaries of the stack gases as they were carried downstream depended upon the chemical reaction between hydrogen-sulphide gas and lead acetate. Vertical indicators were placed at various positions in the wake of the stack and were painted with a lead-acetate mixture. Hydrogen-sulphide gas was emitted from the top of the stack and passed downstream. It combined with the lead acetate to form lead sulphide, thus staining to a dark brown that portion of the indicators with which it came in contact.

Seven principal series of tests were conducted: (1) station model, with stacks; (2) station model, without stacks; (3) isolated stacks, cold gas; (4) isolated stacks, hot gas; (5) nozzle effects; (6) tip-vortex exploration; and (7) scale effects.

PROBABILITY OF DOWNWASH

Fig. 2 shows that the first stage of downwash depends upon

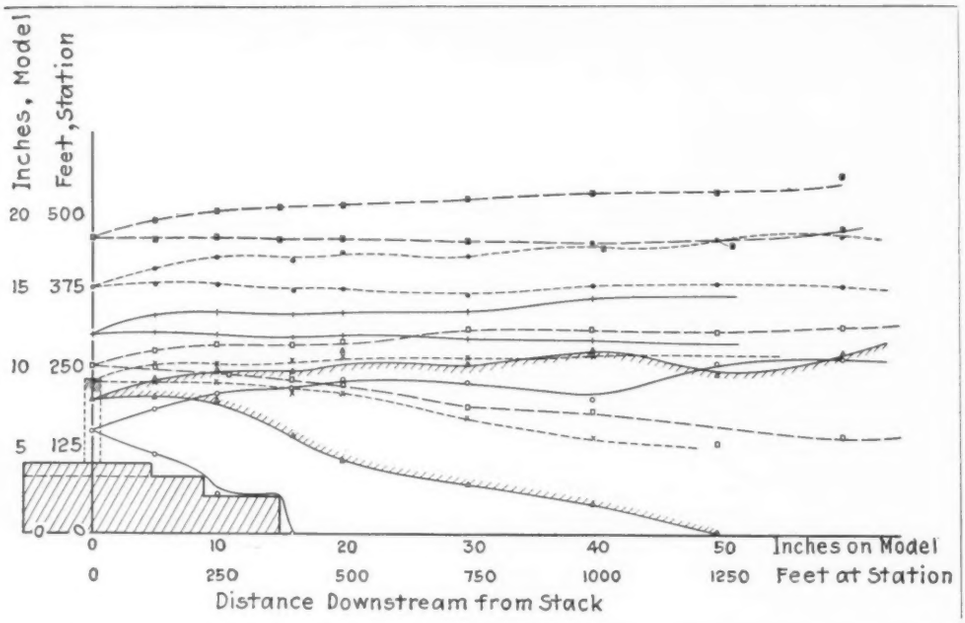


FIG. 4 INFLUENCE OF BUILDING MODEL UPON DOWNWASH, STACKS REMOVED, WIND FROM NORTH

SUMMARY OF CONCLUSIONS

1 The downwash is accomplished in two steps, the first of which is the downwash induced by the tip vortexes at the top of the stack combined with the vertical vortex cylinders in the wake, and the second of which is the dispersion of the gas within the turbulent mass of air above and behind the station buildings, all as shown in Fig. 1. Items 2, 3, 4, 5, and 7, of this summary refer only to the first step of downwash.

2 For any given wind velocity the downwash in the wake may occur only when the velocity of the gases emerging from the top of the stack falls below a certain value, as shown in Fig. 3.

3 For any given combination of wind velocity and stack-gas velocity the temperature of the gas is relatively unimportant as a means of controlling the downwash, as shown in Fig. 2. However, for any constant weight of gas, an increase in temperature results in an increased volume and consequently in an increased stack-gas velocity, thus reducing somewhat the tendency to downwash.

4 A nozzle projecting from the top of the stack acts as though it were a stack of smaller diameter, and the gases in the wake follow the same law of downwash as that shown in Fig. 3, provided that the nozzle projects high enough to escape the influence of the air flow at the junction of the stack and

stack-gas velocity and wind velocity. Stack-gas velocity may be controlled but the wind velocity is a natural phenomenon which must be accepted as it occurs. The Monthly Meteorological Summaries of the U. S. Weather Bureau, Chicago station, from Jan. 1, 1932, to Dec. 31, 1934, show the maximum 5 min average velocity and the fastest mile of wind for every day during this period. This information was used to construct curves showing the frequency of occurrence of the various wind velocities during this period. The data from these curves were combined with those in Fig. 2 to derive the curves shown in Fig. 6, where for any given velocity of the stack gas the percentage chance that downwash will not exceed either 5 min duration or approximately 1 min duration can be read from the curves. Thus, if the stack-gas velocity is 35 fps no downwash exceeding 5 min duration and extending for more than one stack diameter below the top of the stack will occur on 90 per cent of the days. This does not mean, however, that the gas will reach the ground on the remaining 10 per cent of the days, since this would be true only in case the top of the stack extended less than one stack diameter above the turbulent layer of air over the roof of the station building. If the top of the stack extends approximately two diameters above the turbulent layer, and the velocity of the stack gas is 35 fps, then the curves show that no downwash exceeding 5 min duration will occur on 98.2 per cent of the days.

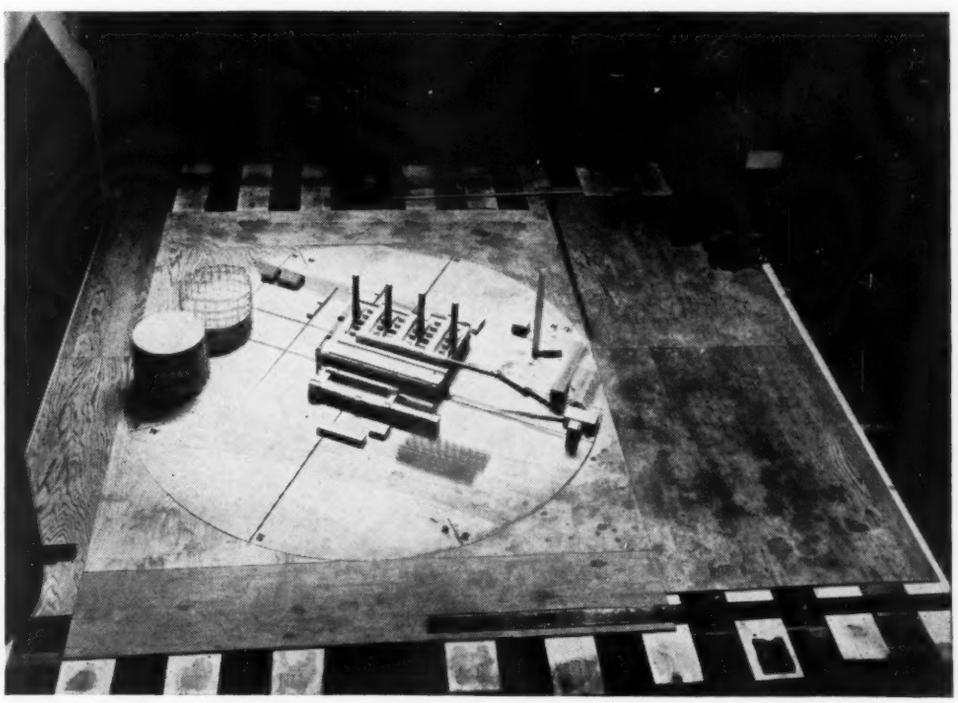


FIG. 5 MODEL IN THE WIND TUNNEL

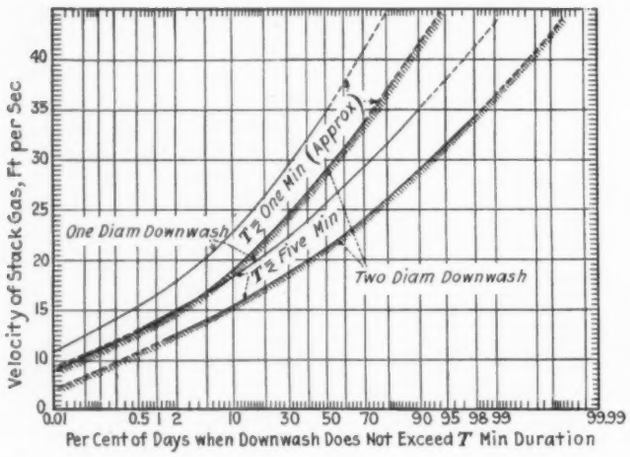


FIG. 6 PROBABILITY OF THE FIRST STAGE OF DOWNWASH AT A STATION IN CHICAGO

nozzle. The critical height of the nozzle is somewhat less than one stack diameter above the top of the stack.

5 The elimination of serious conditions of downwash was obtained by the use of power-operated mechanical devices mounted on the model stack. They have not yet been developed to the point where they can serve as a basis for the design of devices for full-size stacks. An improvement of serious conditions of downwash was obtained by the use of stationary devices on the model stack. None of these are described in this paper.

6 The downwash observed with models is substantially the same as that which would be observed in the field for the same wind velocity, stack-gas velocity, and gas temperature, that is, there are no important errors introduced because of aerodynamic scale effects.

7 Wind velocity is the only significant meteorological factor entering into the downwash of gas in the wake of the stacks. If there is a lower limit to the velocity of the stack gases under ordinary operating conditions, then there will be a corresponding wind velocity below which downwash will never occur. Fig. 6 shows in percentage the chance that downwash of more than one stack diameter, or of more than two diameters, will occur with any given stack velocity. It is based on the frequency with which daily maximum wind velocities of any given value occurred at the U. S. Weather Bureau Station in Chicago during the years 1932, 1933, and 1934.

8 The critical height to which the influence of the buildings extends in bringing down gases depends upon the shape and proportions of the buildings and other structures in the path of the flow. At the Crawford Station the critical height, when the wind is blowing from the southwest across the gas holders, is between 25 and 50 ft higher than the top of the old stacks; for other wind directions the critical height is lower than the top of the stacks, being lowest for south winds, in which case it is more than one stack diameter below the top. The addition of 50 ft to the height of the old stacks would prevent downwash from any direction, provided that the gas velocity is high enough to prevent the first step of downwash. It was recommended that 30 ft be added to the height of the stack together with a nozzle 20 ft high rather than to add 50 ft to the height of the stack. This would provide a greater velocity of stack gas with the accompanying greater resistance to the first step of downwash.

9 Nozzles 18 ft in diameter by 50 ft in height were added to the top of the stacks as shown in Fig. 7. No further downwash was observed at the station.

ACKNOWLEDGMENTS

The authors wish to acknowledge the contributions of M. J. Thompson, Burdell L. Springer, and G. E. Beringer in the design of special apparatus and methods of testing. The project was sponsored by the Commonwealth Edison Company of Chicago, under the direction of W. L. Abbott and Alex D. Bailey, who made valuable suggestions and criticisms as the research work progressed.

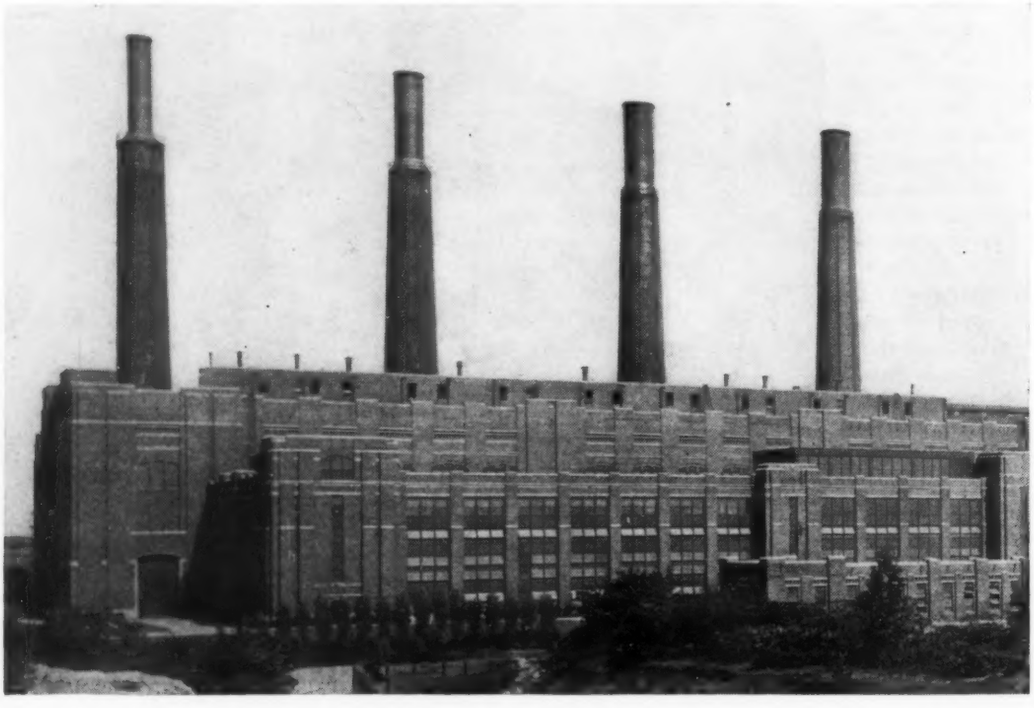


FIG. 7 STATION BUILDING WITH REMODELED STACKS

FIG. 1 EXCESS ACETYLENE FLAME

HARD FACING—*a* PROCESS *for the* MECHANICAL ENGINEER

By E. E. LeVAN

HAYNES STELLITE COMPANY, KOKOMO, IND.

ESSENTIALLY, hard facing consists of welding onto wearing parts a coating, edge, or point of a hard metal, generally a special alloy possessing unusual wear resistance. By this method, metal surfaces which normally wear away rapidly in service are protected. The process can be used with equal advantage for new parts before their first use or for old, worn parts. Hard facing has proved to be an easy and inexpensive means of maintaining production by keeping equipment in good operating condition without losing time for repair or replacement of worn parts.

The most important hard-facing economy results from the increased service life of the equipment. Hard-faced parts will outwear plain or unfaced ones from 2 to 25 times, depending on the type of hard-facing alloy used and the service to which the part is subjected.

This increased life results directly in fewer parts replacements and fewer shutdowns. A reduction in this down time for a machine means an increase in both production and efficiency, particularly of heavier types of equipment, such as dredges, power shovels, and the like, where tie-ups are most expensive.

It is a well-known fact that toughness and hardness of metals do not go hand in hand. Many tools, implements, and machinery parts must be strong and tough because of their very design or function. If such parts are made of tool steel and are heat-treated, a compromise between hardness and toughness must generally be accepted. With parts designed for hard facing, however, the body or parent metal can be a steel that is expressly suited for strength requirements and shock resistance. Only the strength and cheapness of the bulkier base metal need be considered. Then the wearing surfaces can be hard-faced with a suitable wear-resistant material, thus creating a composite part which possesses both strength and hardness, each used where it is needed most. Often plain medium-carbon and low-alloy steels can be used as the base of the part. These have the necessary strength and shock resistance. At the same time, they often make possible considerable savings in material costs.

Contributed by the Machine Shop Practice Division for presentation at the Semi-Annual Meeting, Milwaukee, Wis., June 17–20, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

REQUIREMENTS AND TYPES OF HARD-FACING MATERIALS

High-quality materials are required for hard facing. To be suitable for this purpose they should possess the following properties:

1 Inherent hardness.
2 Resistance to abrasion during use.
3 "Red hardness," or the ability to retain initial hardness up to red heat and to be unaffected after cooling slowly from red heat.
4 Ability of being easily applied by ordinary welding techniques.
5 Resistance to high-temperature oxidation during application by welding.
6 A melting point slightly lower than steel, the usual base metal.
7 A coefficient of expansion close to that of the base metal.

This combination of characteristics is approached by only a few hard-facing materials. Nevertheless, in the 15 or 20 years in which this problem has received careful attention, a great number of wear-resistant alloys and hard-facing rods have been developed which fulfill to a varying extent the foregoing requirements. They may be classified roughly as follows:

Group 1. In this group are included alloys whose cost per pound is low. Practically all of these are hard alloy cast irons

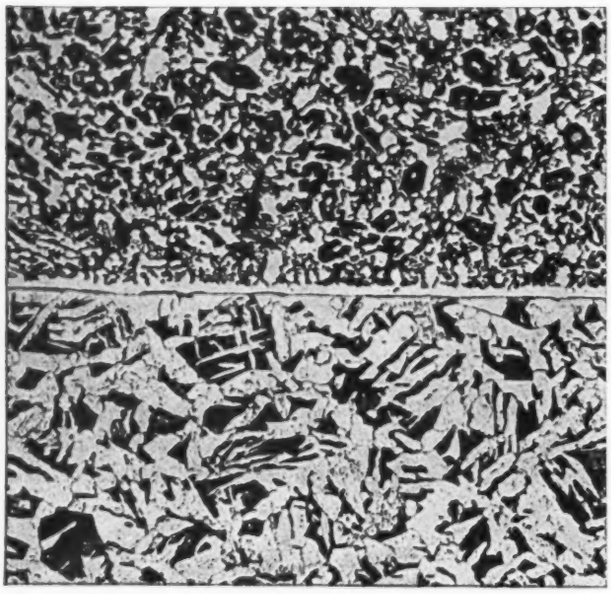


FIG. 2 PHOTOMICROGRAPH SHOWING THE NATURE OF THE CORRECT BOND BETWEEN HARD-FACING ALLOY (UPPER) AND STEEL (LOWER)

(There is practically no penetration, yet the bond is stronger than either the deposited metal or base metal. The deposited alloy possesses maximum wear resistance because it is undiluted with iron.)

or alloy steels containing varying amounts of chromium, tungsten, manganese, or silicon, the total of all of which is usually below 20 per cent. Alloys such as Hascrome, iron-base chromium-manganese rod, have greater wear resistance than ordinary carbon steel.

Group 2. These are metals that contain more than 20 per cent and as much as 50 per cent of one or more of the elements chromium, tungsten, manganese, silicon, cobalt, nickel, and carbon. The new "Haynes 93" rod typifies this group of materials, which are useful for services involving more severely abrasive wear than the metals of group 1 can satisfactorily withstand.

Group 3. This class consists of the group of nonferrous cobalt-chromium-tungsten alloys represented by Haynes Stellite alloys. Their iron content is negligible. The various grades are all highly resistant to abrasive wear and are all hard even in the red-heat range, but they vary in strength and toughness. In this material cobalt is the base of the alloy, whereas iron is the base of the alloys in preceding groups. The hardness is inherent and permanent in that it may not be materially altered by heat-treatment.

Group 4. In this group are the tungsten-carbide particles which are held in place on wearing surfaces by high-strength steel. The tungsten-carbide particles are not melted with the oxyacetylene flame, so hard-facing materials of this group are furnished in two forms, tube rods (steel tubes filled with the tungsten-carbide particles) and composite rods in which the particles are bonded in steel. Both types are applied in the same way and result in a deposit wherein the hard particles are firmly anchored on the wearing surface by the steel tie-in metal. Haystellite tube rod and Haystellite composite rod typify this group.

Group 5. This subdivision consists of small individual castings or inserts of tungsten carbide. These are laid in a groove on the surface of, for instance, the blades of an oil-well drilling bit and are bonded in place with a steel welding rod. Haystellite inserts, which fall into this group, and the Haystellite rods of group 4 are used on oil-well bits and the digging edges of many types of excavating equipment.

Selection of the most suitable hard-facing metal for each particular job must take into consideration finished cost, maintenance, cost of shutdowns for repair or replacement, and service life. As a rule, the higher-quality material will prove more economical in the long run, despite its comparatively higher first cost. From tests of alloys of each of the foregoing groups in strictly comparative service, a prediction of the relative service life can be made. Using the life of carbon steel as unity, these will be about as follows:

Group 1	1 to 2
Group 2	2 to 4
Group 3	3 to 10
Group 4	10 to 25
Group 5	10 to 25

The mechanism of wear involves such a large number of interdependent factors that single isolated tests can rarely approximate service conditions. Many devices for determining the wear of metals have been designed and used, but it is usually admitted by the designers that the results of these specific tests show only the resistance of the metal under test to the limiting wearing conditions imposed by the testing machine.

It is also a fact that cold hardness of an alloy is not a true indication of its wear resistance, and it does not necessarily follow on hard-facing applications generally that the alloy possessing the highest cold hardness will outperform comparatively softer hard-facing alloys.

It is probably true that as a rule harder alloys will wear less rapidly than softer ones, but the effective hardness is the actual hardness under working temperatures. Red hardness, or the ability of an alloy to retain its original hardness practically unimpaired at surface heats developed by friction and even at red heat, accounts for the superior results of hard-facing alloys.

Therefore, in view of the varying characteristics of the different hard-facing alloys and the conditions of the operation, which apparently cannot be reproduced in laboratory tests, it would seem important to determine the value of the hard-facing alloy from results on actual operations or field tests.

FIG. 3 OIL-WELL DRILLING BITS HARD-SET AND HARD-FACED, FOR LONG DRILLING LIFE, WITH CAST TUNGSTEN-CARBIDE INSERTS AND TUBE RODS

MATERIALS WHICH CAN BE HARD-FACED

In general most steels can be hard-faced readily. Those containing over 0.50 per cent carbon must usually be heat-treated, however, and the hard facing of high-speed steels is unsatisfactory. Low-alloy and stainless steels, gray cast iron, alloy cast iron, and nickel-base alloys are also hard-faced successfully. Brass, bronze, copper, and aluminum are difficult, if not impossible, to hard-face because of their low melting points, but parts made of these metals and alloys can be rebuilt to their original size by welding methods, using welding rods of the same alloy.

PREPARATION OF WORK

All loose scale, dirt, rust, or other foreign substances should be removed from the areas to be hard-faced, preferably by grinding or machining. The base metal should be clean.

Where the hard-facing material is to be applied to a groove, corner, or recess, it is preferable to have all corners well rounded, otherwise local overheating of the base metal may result. If but a small section of a part is to be hard-faced, a suitable shallow recess, groove, or indentation to receive the hard-facing metal may be prepared either mechanically or with the oxyacetylene cutting blowpipe.

The same general rules apply to preheating before hard-facing as apply to most welding operations. Parts are always preheated in cases where the application of the hard-facing alloy would otherwise cause them to warp or check, or where time and welding gases can be saved by preheating. Steels having over 0.50 per cent carbon should usually be preheated.

WELDING METHODS

Although hard-facing materials can be applied by any of the standard fusion-welding methods, there are several factors which govern the choice of method for any particular application.

For the majority of hard-facing applications, the oxyacetylene process is employed. The oxyacetylene flame allows close control over the operation and produces a smooth deposit. Particles of scale and foreign matter are easily eliminated by this method, and edges and corners can be formed readily. Other advantages include the elimination of any loss of expensive alloys by vaporization or spattering, close control of the oxidizing or reducing conditions of the atmosphere surrounding the molten metal, and accurate control over the degree of penetration of hard-facing alloy in the base metal. This latter advantage is of importance, especially with respect to the application of certain classes of hard-facing materials, some of which should be puddled in, while others are flowed onto the base material at a "sweating" heat. The oxyacetylene process offers the facilities for producing either condition at the will of the operator.

OXYACETYLENE TECHNIQUE

Hard-facing practice with the oxyacetylene flame varies depending upon the nature of the metal being deposited. Having had the most of his experience with group 3 alloy, the author proposes to describe the process as practiced in the use of cobalt-chromium-tungsten hard-facing rods, but fundamentally a similar method should be pursued for applying almost any hard-facing alloy by the oxyacetylene method. The recommended practice is actually welding without appreciable penetration.

The blowpipe should be adjusted to a carburizing flame with the tip of the outer cone extending almost three times the length of the inner cone, Fig. 1. A tip sufficiently large to hold the heat in the body metal should be used. The flame lends a little carbon to the hot, unmelted steel, converting a very thin surface film to a high-carbon steel with a much lower melting point. Hence this film will melt and the surface appear to "sweat" before any measurable part of the base metal is heated to its real melting range. When this occurs, the rod should be held directly beneath or beside the flame, and as the alloy melts from the rod it will spread freely over the sweating surface. Any scale met with or formed in the course of the work should be floated off by manipulation of the flame to avoid pinholes in the deposit.

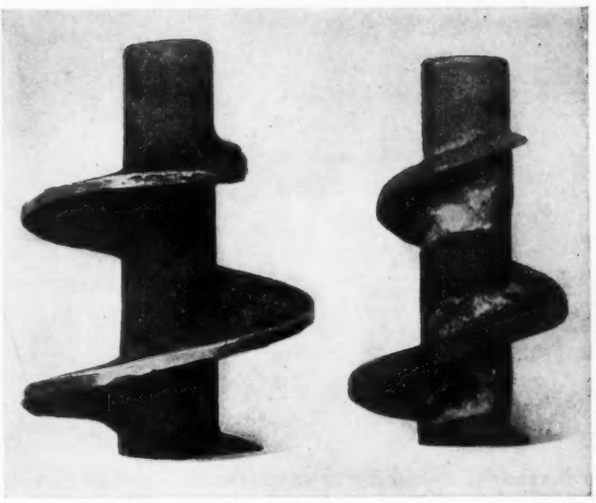


FIG. 4 ELECTRIC-MUD-GUN SCREWS SHOW THE ABRASION RESISTANCE OF HARD-FACING ALLOY: LEFT, A HARD-FACED SCREW AFTER FOUR MONTHS' SERVICE; RIGHT, ORDINARY SCREW AFTER ONE MONTH OF SERVICE

The very thin original sweated layer forming the bond between the base metal and the hard-facing alloy, Fig. 2, possesses greater strength and toughness than either the base metal or the hard-facing alloy, due to the interalloying of the two metals in this thin layer.

METALLIC-ARC PROCEDURE

With the metallic arc, a certain amount of interalloying is unavoidable, although it can be kept at a minimum through careful control. For coverage of large areas the arc process is more economical, and it is frequently employed if rough surfaces and some cracking or checking of the hard-facing metal are not objectionable. Reversed polarity should be the rule in depositing all high-chromium alloys with the arc. Power consumption is fairly heavy.

The metallic arc is always used when hard-facing Hadfield's or 13 per cent manganese steel as, for instance, on steam-shovel bucket teeth, or crusher jaws and mantles. When this steel is heated to the welding temperature and cooled in the ordinary way, it becomes brittle. Furthermore, its coefficient of expansion is about 50 per cent greater than that of a hard-facing alloy of group 3. The steel can be restored to its original ductility by quenching the hard-faced part from about 1830 F in water.

HARD-FACING APPLICATIONS

One of the first and most important uses for hard facing was on the cutting and reaming edges of oil-well drilling tools, which formerly were shop-dressed and tempered steel, Fig. 3. In a well at Pierce Junction, Texas, 80 standard steel rotary bits drilled a well to a depth of 3600 ft in 629 hr. With hard-faced bits in an offset well, it was possible to drill to the same depth and through the same formations in 406 hr with 44 bits. This represented a saving of 223 hr of time and the cost of 36 drilling tools. The steel bits drilled an average of 45 ft per bit; whereas

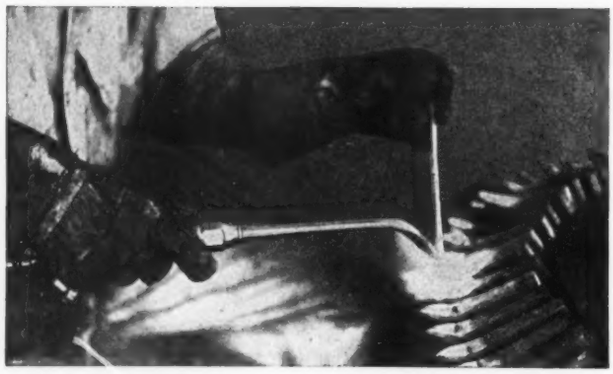


FIG. 5 TIPPING UNDERCUTTER BITS FOR COAL CUTTING MACHINES WITH HARD-FACING ALLOYS IS STANDARD PRACTICE IN MANY MINES

the bits hard-faced with a group-3 alloy averaged 82 ft of hole per bit. Today it takes only 14 bits hard-set and hard-faced with alloys of groups 4 and 5 to accomplish the same job.

The iron and steel industry is now a large user of hard-facing materials. Some of the parts regularly hard-faced are blast-furnace clay-gun screws and nozzles (Fig. 4), tap-hole augers, gag-press hammers, rolling-mill guides, tube-drawing mandrels, hot-shear blades, and hot-work punches and dies. The excavating and mining industry, the railroad industry, and steam power plants all use these alloys in substantial quantities.

One of the important fields where the mechanical engineer has to keep machinery operating under adverse conditions is in mining, quarrying, and excavating, for here the mechanical equipment has to contend with severe abrasion and generally a considerable amount of impact, in order to loosen and remove the various ores, rock, sand, and gravel.

IN MINING COAL

An interesting application of hard facing in mines is undercutter bits for cutting coal, Fig. 5. That hard facing has again come to the aid of the mechanical engineer responsible for this equipment is shown by tests at a large shaft mine where bits hard-faced with an alloy of group 3 cut three to six times more coal per grind than ordinary bits. At this mine it takes two men ten to twenty minutes to change a set of bits in the undercutter machine. The fact that the hard-faced bits last from three to six times as long as ordinary steel bits means a great saving in down time of the machine and an additional production of coal per man per hour. The mine in question made an estimate, which they considered conservative, that the saving in bit cost was over 50 per cent. Also, a saving of from 22 to 27 per cent in power consumption was estimated because the hard-faced bits stayed sharp longer than ordinary bits, enabling the machine to cut more easily.

IN TRANSPORTATION

At railroad transfer points, it is necessary to redistribute the freight cars. On most roads this is done in classification yards where the cars are controlled by car-retarder systems. In the retarder systems, many parts are subjected to constant abrasion and tend to wear rapidly. Driving-link lugs and pins, hold-down bars, yokes, spacers, dust-shield plates, brake shoes, and other parts have to remain mechanically accurate in order to have the mechanism function properly.

When a retarder needs repairs, the entire unit is disconnected, removed from service, and a replacement unit is installed while the worn unit is being repaired, Fig. 6. The replacement requires about two hours and during that time that particular track is out of service. A spokesman for one railroad reports that the number of wearing parts to be hard-faced in one unit is 684. Complete repair of a retarder unit takes from 4 to 5 weeks. Here, in this classification yard, twenty-four retarders have now been completely rebuilt and hard-faced and have given exceptionally good service over a period of several years.

Another interesting application in railroad yards is on plates at interlocked switches. When the worn plates were hard-faced, it was found that ice and snow would not adhere to the alloy surface, thereby enabling the switch to be operated easily in ice or snow. This lack of adherence is probably due to the fact that the surface of the alloy, when ground, takes a very high, smooth finish and retains it without corrosion or rusting, regardless of weather conditions.

IN POWER PLANTS

Coal is frequently pulverized in swing hammer mills, the hammers of which are subjected to severe abrasion and impact. The use of a medium-carbon steel as the base metal of the hammers, with a layer of hard-facing alloy on the striking face, results in long-lived, economically operated hammers. In one plant a set of hard-faced hammers pulverized 223,000 tons of coal as compared with 38,000 tons pulverized by the tool-steel hammers formerly used.

High-pressure, high-temperature steam presents a problem to the mechanical engineer, who must provide valves which will stay on the job day in and day out without leaking. The modern trend in steam is toward higher temperatures and pressures and we now find valves handling steam under pressures as high as 1500 psi at temperatures up to 950 F.

Hard-facing alloy has been adopted by modern steam plants to protect the seating surfaces of these high-pressure high-temperature valves, Fig. 7. In fact, this application is of so much importance to present-day steam plant operation that valves hard-faced with the alloy are now available from practically all valve manufacturers. Many examples could be cited of the long life of hard-faced valves but one or two will suffice.

In an eastern power station, a hard-faced 12-in. gate valve in the high-pressure line for a 50,000-kw turbogenerator operated

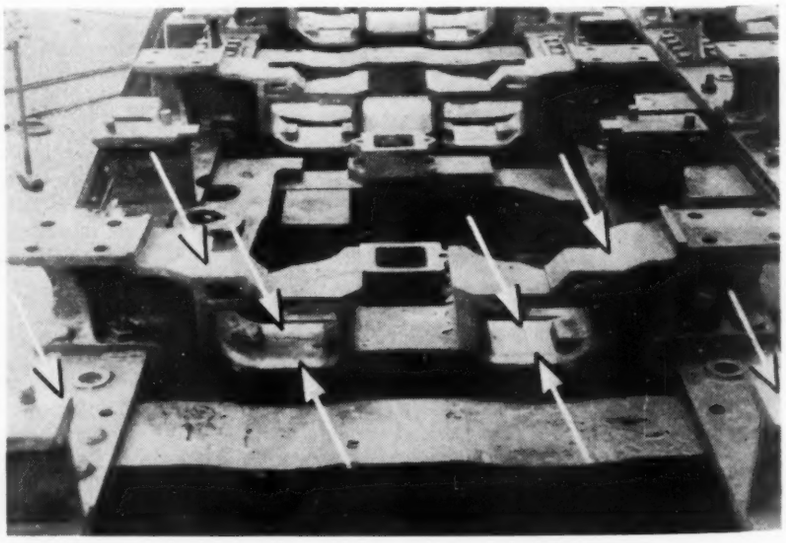


FIG. 6 CAR RETARDER SHOWING A FEW OF THE SURFACES—SPACERS OR DUST SHIELDS, YOKES, AND OTHER PARTS MOUNTED ON THE FRAME—THAT ARE HARD-FACED

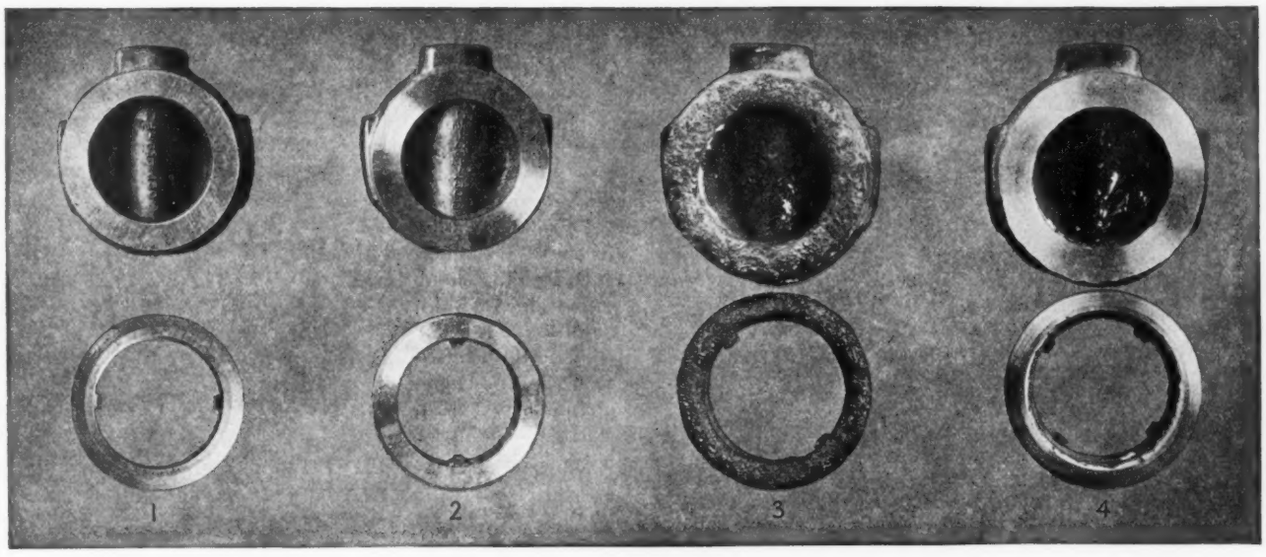


FIG. 7 HARD-FACED STEAM-VALVE GATES AND RINGS
(1 Original surfaces; 2 Surfaces rough-machined; 3 Hard-facing alloy is applied; 4 Surfaces finish-ground and ready for service.)

for more than a year at 1250 psi pressure and 950 F and was still leakproof and trouble-free.

In another plant, a 5-in. 900-psi globe valve, which had been hard-faced, operated without any repairs for 23,570 hr, almost three years, in a line carrying steam at 650 psi and 850 F, and was still in use.

The long, trouble-free, leakproof life of hard-faced valves has enabled designers to use welded-bonnet construction to insure tightness at the high pressures. Many welded-bonnet valves are now being installed. In some cases, the hard-faced seat rings are being welded in place instead of screwed in place in gate valves, eliminating another leakage hazard. This is made possible because the long life of the hard-faced seat rings obviates the need of frequent replacement.

The extent to which hard-faced steam valves have been accepted by power plants and other users of steam is perhaps best illustrated by a published statement of one valve manufacturer to the effect that in the first eight-month period of 1938 the company produced a total of 52,624 valves with hard-facing alloy seating surfaces.

Another job which presented difficulties, now solved by the use of hard-facing alloy, is that of obtaining long-lived steam-turbine blades. When it is considered that the tip ends of turbine blades move at speeds as high as 750 mph and must withstand the impact of moisture droplets condensed from the steam, it is obvious that the best materials must be used to withstand this action. One solution has been to use shielding strips on the blades, Fig. 8. These strips are made of a grade of hard-facing alloy which can be rolled, with some difficulty, and formed to the proper shape. The strips are applied to the turbine blades by silver-soldering. After many comprehensive tests these alloy strips have been adopted by three of the largest turbine manufacturers because their performance has fully confirmed initial laboratory tests.

IN OIL PRODUCTION

When an oil well is completed and flows naturally as a "gusher," its flow is controlled through a set of valves and pipe connections known as a "Christmas tree." The valves are subjected not only to the flow of the fluid at high pressure and speed, a condition tending to erode and wiredraw the seating surfaces, but also, in some cases, to corrosion due to sulphur compounds in the oil, and also to the abrasive action of the sand which usually accompanies the oil. This set of conditions requires valve seating surfaces which withstand all of these actions. Hard-facing alloy again filled the need and is widely used on valves for flowing wells.

In oil refineries, various valves handling hot and cold fluids, some of which are corrosive, are being hard-faced with resultant increases in life and valve efficiency.

Another oil-refinery application worthy of mention is the

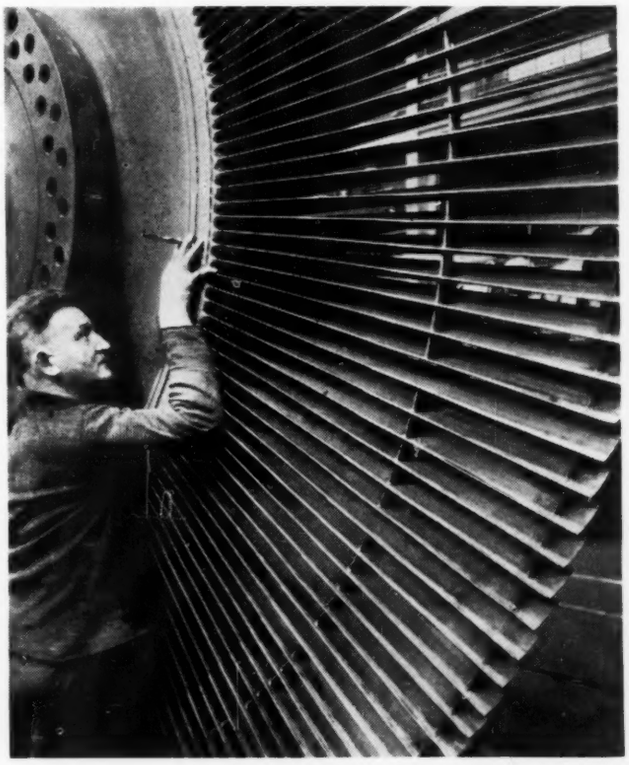


FIG. 8 SHIELDINGS OF HARD-FACING ALLOY TO PROTECT STAINLESS-STEEL TURBINE BLADES FROM THE EROSION CAUSED BY CONDENSED MOISTURE IN THE LOW-PRESSURE STAGES

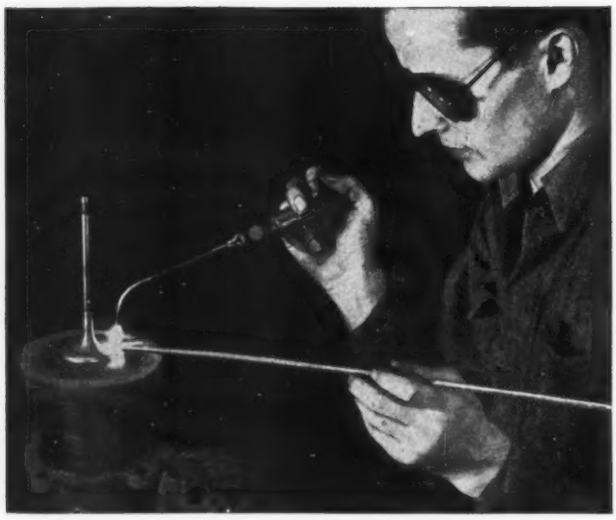


FIG. 9 HARD-FACING ALLOY APPLIED TO THE SEATING SURFACE OF AN AUTOMOTIVE VALVE FOR GREATLY INCREASED LIFE

use of hard-facing alloy on pump-shaft sleeves. Several pump manufacturers have standardized on hard-faced shaft sleeves in centrifugal pumps handling hot oil. The impeller tips in the centrifugal hot-oil pumps are also often hard-faced to resist the corrosion and erosion which occur rather rapidly in ordinary steel parts under certain operating conditions.

One of the outstanding advantages of hard-facing alloy used on the shaft sleeves of centrifugal pumps is the saving made in packing. Because the alloy surface does not corrode or pit or wear away, it retains its high finish and does not create as much friction against the packing as would be the case if a steel shaft or sleeve were used.

INTERNAL-COMBUSTION-ENGINE VALVES

There are, of course, many other types of valves which operate under difficult service conditions. Valves and valve seats of automotive, aircraft, and Diesel engines, for instance, are subjected to a combination of heat and corrosion from the products of combustion; abrasion and deformation from impact; and erosion resulting from "blow-by" of gases, which occurs if the valves do not close tightly. The resistance of hard-facing alloy to corrosion and erosion, and its retention of hardness even when subjected to the high temperatures of the hot exhaust gases, indicated its possible use for the seating surfaces of valves and valve seats of gasoline and Diesel engines, Fig. 9. At present, many heavy-duty truck and bus motors are equipped with hard-faced valve-seat inserts or valves.

A large operator of buses, who maintains accurate records of valve performance, reported that hard-faced valves, after 110,000 miles of use in passenger-bus service, were in excellent condition—still operating economically without loss of compression. This performance compares with 10,000 to 20,000 miles of operation of the best grades of steel valves before valve grinding is advisable.

The next natural step was the use of hard-faced exhaust valves in aircraft engines. By prolonging the life of these valves through hard facing, the flying life between interruptions for valve repair and replacements has been lengthened and the operating costs have been reduced, because the hard-faced valves perform their proper function so much longer, assuring full continuous engine power. They also contribute considerably to the safety of the pilot and the passengers.

The conditions in aircraft engines are much more severe than in automotive engines, and hard-faced valves have proved their ability to resist the severe conditions of aircraft operation and the corrosive effect of hot exhaust gases at temperatures probably as high as 1500 F. The engineering department of one of the large air lines reported to a valve manufacturer that hard-faced valves removed after 4080 hr of service were still in excellent condition, even to the extent that the grinding and finishing marks could still be seen. This compares with the usual run of about 500 hr with high-grade steel valves that have not been hard-faced. The time of 4080 hr in the air means the remarkable total of 714,000 air-miles of efficient, uninterrupted service, Fig. 10.

There are multitudes of other applications—and even whole industries—using hard facing which have not been mentioned here. An attempt has been made, however, to give an idea of what hard facing means and the savings made possible by its use, in order to indicate to the mechanical engineer the types of equipment in which this economical industrial process can be used to advantage.

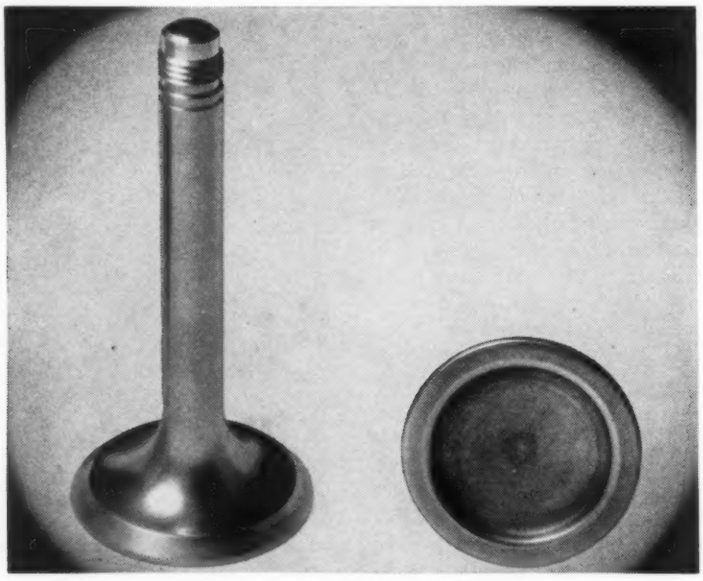


FIG. 10 HARD-FACED, SODIUM-COOLED EXHAUST VALVES AFTER 4080 HR, OR 714,000 AIR-MILES, IN AN AIRCRAFT ENGINE

A Study of HEAT-INSULATION PROBLEMS *in* STEAM POWER PLANTS

By E. T. COPE and W. F. KINNEY

THE DETROIT EDISON COMPANY, DETROIT, MICH.

DURING the last thirty years, investigations of heat insulation have been confined largely to studies of mechanical and thermal properties of materials but little attention has been given to the method and cost of installation. During this period, the wage rate for labor employed in assembling heat insulation has been rising steadily, as shown in Fig. 1, and now has reached such a point that it should be

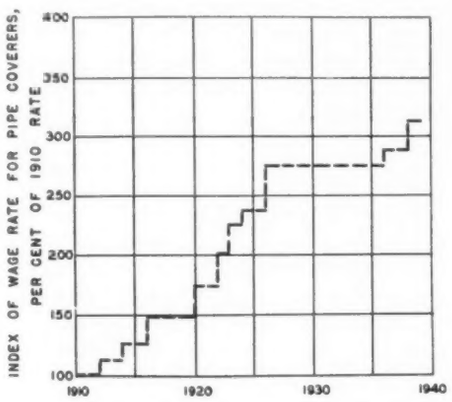


FIG. 1 TREND IN CONSTRUCTION LABOR COST IN A REPRESENTATIVE ELECTRIC UTILITY COMPANY

given greater consideration. The expenditure for labor is affected not only by the wage rate of the workmen but also by the form of materials used and the technique of assembly, both of which influence the time that is required to cover a unit area.

The study of heat insulation in this instance resolves itself into a consideration of the convenience of application, cost of construction, and permanence, as related to installations on furnace walls, ducts, fan housings, piping for hot and cold fluids, and steam turbines. Certain problems are encountered in producing an economical, permanent, and neat installation. Some of these have been dealt with and reasonably satisfactory solutions reached; some are being investigated and progress has been made; still others exist that have been recognized only recently.

It is the authors' belief that improvements can be made most rapidly by bringing into the open the problems involved. The purpose of this paper is to introduce certain of these problems and to describe some unusual techniques of installation, with a view toward provoking discussion of these matters.

Contributed by the Power Division for presentation at the Semi-Annual Meeting, Milwaukee, Wis., June 17–20, 1940, of The American Society of Mechanical Engineers.

DISCUSSION OF INSTALLATIONS ON VARIOUS KINDS OF EQUIPMENT

FURNACE WALLS

The attainment of ideal conditions in connection with the insulation of boiler-furnace walls depends on (*a*) sufficient thickness of material to yield a temperature of the outside surface of the wall that will permit comfortable working conditions and (*b*) complete prevention of the infiltration of air into the furnace.

Actually, it is possible to control the outside-surface temperature by use of an adequate thickness of any one of the common forms of heat insulation, namely, block, blanket, or insulating cement, but there is a need for designs for installations that will effect a permanent sealing of the furnace walls and that will be reasonable in installed cost.

It is common experience in steam-generating plants to find that cracks develop in the insulation on water-cooled furnace walls as the result of (*a*) expansion and contraction of the setting, (*b*) shrinkage of the material, (*c*) settling of the material, or (*d*) loosening of the material due to faulty attachment. Because of the likelihood of air infiltration as a result of this situation and to provide a pleasing external appearance, it is frequently considered necessary to encase waterwall furnaces in airtight steel shells, which in turn may require insulation.

Typical examples of designs recommended by various insulation manufacturers and consumers are illustrated in Fig. 2.

Experience has shown that it is virtually impossible to maintain any of these assemblies airtight over a long period of time unless all-welded steel casings are provided, but this is an elabo-

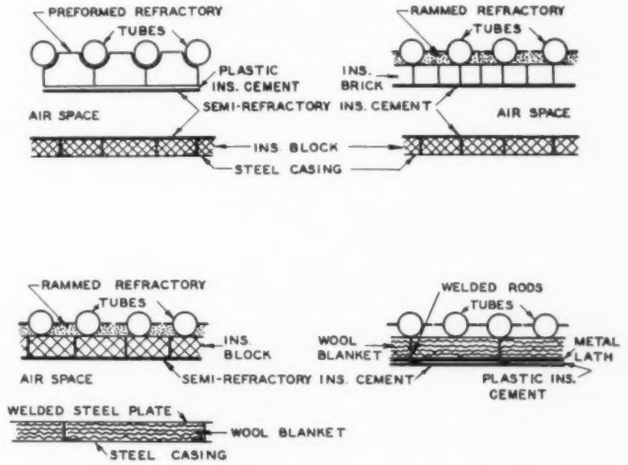


FIG. 2 TYPICAL INSULATION CONSTRUCTION ON WATER-COOLED FURNACE WALLS

rate and expensive construction. This is one kind of insulation problem for which a satisfactory answer has not yet become evident.

DUCTS AND FAN HOUSINGS

Large areas comprising air ducts, breechings, fan housings, tanks, and similar equipment are subjected to vibration and considerable expansion and contraction. They are usually located where they are liable to frequent abuse near the floor level. The presence of hot gases varying from perhaps 100 to 600 F on the inside of the wall with insulation on the exterior is conducive to a great deal of warping and irregular movement, which in turn affects the tightness of the insulation. Expansion joints are usually installed in various locations on the equipment to provide for this movement but there is seldom a provision for the movement of the exterior insulation on the sheet metal. It is difficult to retain blocks, blankets, or insulating cement on a surface where so much relative movement and vibration take place, and it is obvious that unless extreme precautions are taken during installation, loosening of the insulation will be a recurring problem.

Thus, this problem resolves itself into one of design rather than selection of materials. It is assumed that the insulation thickness has been determined that will reduce the temperature of the outside surface to a comfortable degree and that the form of material will permit economical installation.

There are several conditions that must be met in designing insulation for such service. First, there should be little if any through-metal connecting the inside and outside surfaces of the insulation, as burnt canvas and paint result from conduction to the outer surface. Second, there should be ample insulation over stiffeners to prevent excessive spot temperatures on the outer surfaces. However, for the sake of appearance it is not always desirable to place humps of insulation over the stiffeners. Third, some type of expansion joint should be provided in exterior insulation in order to make allowance for expansion and contraction of the metal. Assuming these three conditions can be met, there is no reason why large exterior surfaces on ducts, fan housings, and tanks cannot present a smooth crack-free surface with no burnt canvas or paint.

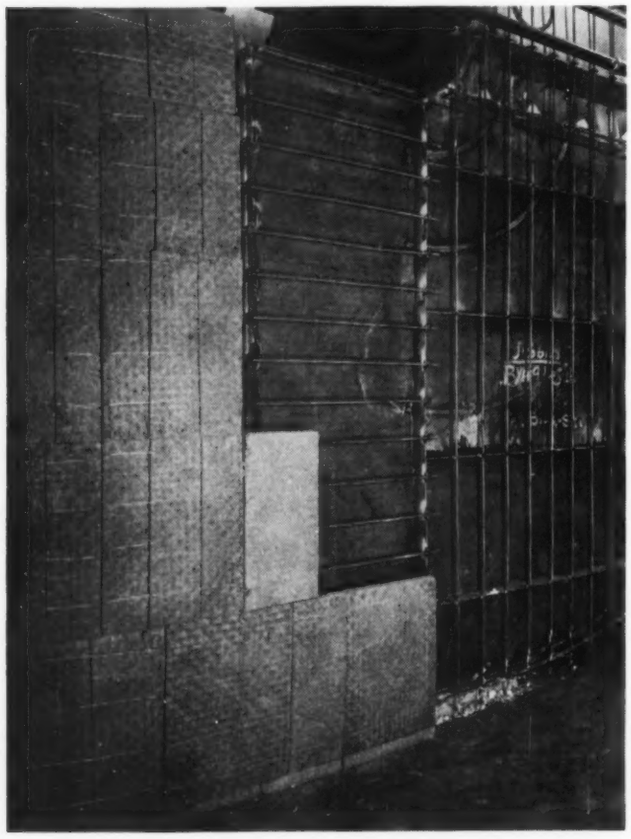


FIG. 3 METHOD OF APPLYING BLOCK INSULATION TO PREHEATED-AIR DUCTS

There are probably more different types of installation on this equipment than on any other, owing to the fact that insulation designers have a variety of opinions as to what requirements should be met in the field. Certain products and specific methods of installation have been strongly recommended and, while the completed job appears to be satisfactory, yet after a period of service there is evidence of sagging insulation, damaged corners, and irregular gaping cracks in the torn canvas. In order to remedy this unsightly appearance, maintenance of these surfaces becomes a routine expense.

One design, which was quite successful but fairly expensive, is shown in Fig. 3. This photograph illustrates the application of 18 × 24-in. blocks wired onto a grill of reinforcing rods held loosely in position by threaded steel nuts welded to the casing. This design makes it possible to obtain a continuous surface without projecting stiffeners, and burning of the canvas and paint is eliminated. However, the curved surfaces are prone to buckle owing to the movement of the metal casing underneath, and cracks develop in the finishing cement at the block joints. Further improvement in design will tend to preclude these difficulties.

It is significant that changes in the form and quality of insulation recently installed on an air-preheater casing effected a saving of 43 per cent in the cost of material and 43 per cent in the cost of labor as compared to a former practice which had been followed for a number of years.

In view of the requisites for such types of installation, it is obvious that an effort should be made to design and install insulation on the inside of ducts without incurring the objections mentioned.

Certainly, there has been sufficient experience and ingenuity in the field to bring to light a combination of the best elements in various types of installations to overcome the difficulties that are everyday occurrences in most power plants.

PIPING AND ACCESSORIES

Large High-Temperature Piping

In modern steam power plants, the thousands of feet of piping of different sizes operating at various temperatures present several problems to insulation-conscious engineers. First, the conservation of heat is important, therefore, the economic thickness of pipe covering should be used. The determination of the economic thickness of thermal insulation[1] involves consideration of several items, namely, net cost of material, cost of heat, cost of construction labor per unit of area insulated, temperature of the surroundings, thermal conductivities of the materials to be used, and fixed charges in the form of interest, depreciation, and taxes. While most of these items have not changed materially during the last twenty years, as already mentioned, the cost of construction labor has continued to rise so that more consideration should be given to means for restricting the portion of the total installed cost attributable to construction.

Second, the ease of installation, final appearance, and permanence in service are factors that enter into the design of

[1] "The Rational Design of Pipe Covering for Pipes Carrying Steam Up to 800 F," by W. A. Carter and E. T. Cope, Trans. A.S.M.E., vol. 47, 1925, p. 255.

covering on pipes, bends, and fittings. The selection and installation of sectional covering on pipes less than 10 in. nps (nominal pipe size) presents no particular problem today other than the selection of the quality and thickness of material to be installed. Products such as cork, rock cork, hair felt, wool felt, laminated sheet asbestos, air-cell asbestos, 85 per cent magnesia, exfoliated vermiculite, amosite (brown) asbestos, diatomaceous earth with asbestos, and glass wool or rock wool cover the entire range of service temperatures from sub-zero to 1200 F and are available as sectional pipe covering, blocks, or sheets. It has been observed that owing to the availability of many kinds of covering which are manufactured in sectional form for pipes less than 10 in. nps and owing to the fact that the expansion and contraction of pipes operating at temperatures below about 600 F are not sufficient to cause serious wrinkling of the canvas jacket, it is not necessary to follow an elaborate technique of installation. However, a very definite problem arises with piping 10 in. nps and larger operating at temperatures above 600 F. Most of the main steam piping in power plants is in this category. Inasmuch as the problems pertaining to large-size piping for high temperatures are somewhat related in cause and effect, the simplest way of presenting the information is to relate some actual experiences.

Curved segmental blocks were available for large pipes, but these were considered expensive. Also, in keeping with standardization practices within the company, flat blocks could be universally used for all large pipes whereas segmental blocks had to be stocked for each pipe size. Therefore, it had been the practice to cover large pipes with 3-in-wide flat blocks, single or double layer, of an appropriate material and thickness for the temperature involved. In this procedure, which was usually followed on pipes while at room temperature, the joints on the inner and outer layers were staggered circumferentially and longitudinally; the blocks were wired in place; asbestos insulating cement was applied on both layers; and the outside was troweled to a smooth surface, covered with canvas, and painted. The completed job was quite presentable although considerable labor was required. However, after a period in service in which shutdowns occurred, expansion and contraction of the piping caused movement in the block construction. Severe cracking in the cement and canvas resulted, particularly at the butt ends of the blocks. It was not long before the canvas, stiffened by successive coats of paint, wrinkled and cracked so badly that it became unsightly and required frequent maintenance. This problem, therefore, resolved itself into designing an installation that would be free from cracking of the canvas jacket without entailing prohibitive installed costs.

The first step taken was the investigation of materials that were commercially available in the form of sectional covering for pipes 10 in. nps and larger and that would prove satisfactory for service up to about 1000 F. Consideration was next directed toward a suitable design of installation for this product. The construction of three identical new boilers afforded an opportunity to compare the previous practice using flat blocks and cement on straight lengths of the 10-, 12-, and 14-in. nps superheated-steam pipes from the first two boilers with subsequent installations of double-layer sectional covering in similar locations on the third boiler. This large sectional covering was light and firm enough to permit handling on scaffolds and could be readily cut in the field with little dust resulting, all of which were advantageous characteristics. It was secured in place with $^3/_4$-in-wide strap-steel bands appropriately spaced. Three adjacent 3-ft sections, stapled together at the circumferential joints with 2-in-wide staples were covered with canvas as a unit to provide a continuous run of 9 ft of pipe covering. The joints between these 9-ft units as well as the joints adjacent to the block-covered bends were not stapled, cemented, or canvased but after they had opened about $^3/_8$ in. owing to the expansion of the pipe in service at 900 F, resilient curly glass wool was installed. Finally, each expansion joint was covered with a light-gage metal band fitted loosely in place to permit free movement of the covering beneath. The painted ensemble is neat, durable, and economical. The principal features of this type of assembly are sketched in Fig. 4.

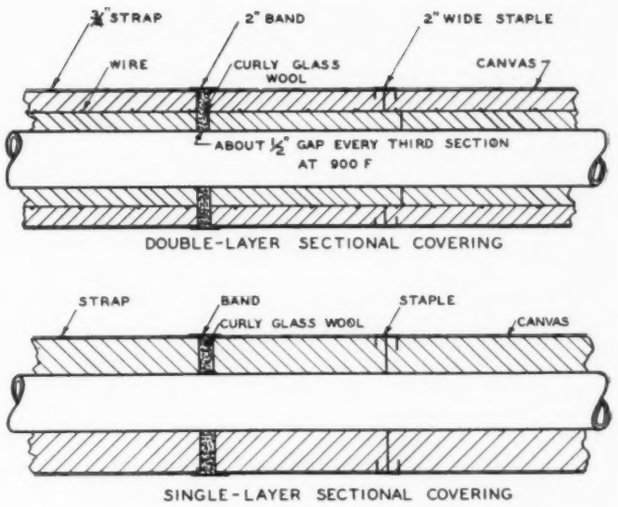


FIG. 4 ASSEMBLY OF SECTIONAL INSULATION FOR LARGE HIGH-TEMPERATURE PIPES

To state that this type of installation was entirely successful would be unduly optimistic, as some shortcomings developed which required further attention in later designs. Some sections, which fitted too tightly on the pipe, held fast when the pipe expanded in diameter and tended to move with it, causing some stapled joints to separate enough to wrinkle the canvas when the pipe cooled on being taken out of service. In general, the shortcomings of the previous practice were largely overcome.

The second stage of this program consisted of securing sectional pipe covering for these large pipes, composed of a high-temperature and a low-temperature material combined into a single layer, with sufficient tolerance in the inside diameter to permit from 0 to $^1/_8$-in. clearance between the pipe and its covering, depending on the usual variations in the outside diameter of the pipe. The same method of installation was followed for this single-layer covering as for the previous double-layer application. The nuisance of cracked canvas was practically eliminated.

Naturally, this departure from long-accepted pipe-covering practices introduces many questions. For instance, is there an abnormal heat loss at the straight-through butt joints on such a single-layer construction? That an abnormal heat loss does not occur at such joints is demonstrated by results of a test recently conducted by an insulation manufacturer in which three test sections of pipe covering to which had been added a temperature-responsive organic indicator were heated for a considerable period on a pipe at 950 F. This conclusion is based on the fact that the isothermal lines visible in Fig. 5 pass straight across the butt joints. However, if the heat loss had been abnormal at these joints the isothermal lines would be bent. This condition is apparent at the exposed ends where the heat was rapidly dissipated into the air.

Another pertinent question concerns the necessity for the pains taken to avoid the unsightliness and maintenance expense due to torn canvas. Company policy governs the standard of appearance and durability which all construction work

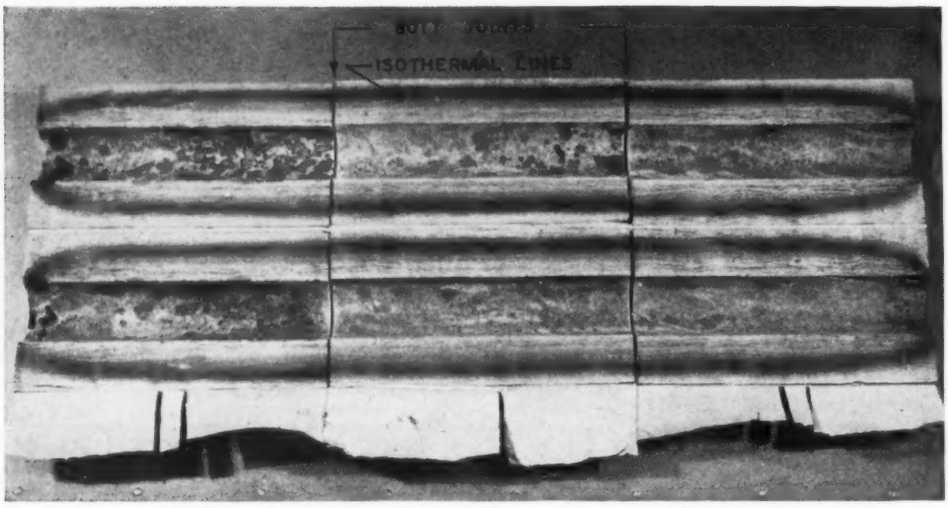


FIG. 5 EFFECT OF THROUGH-JOINTS IN A SINGLE-LAYER CONSTRUCTION ON THE UNIFORMITY OF HEAT LOSS

must meet. Thus, the request that the occurrence of wrinkled, torn canvas on insulated surfaces be eliminated or at least minimized was an important factor in this program.

It might be mentioned at this time that burning and peeling of canvas and discoloration of the paint on surfaces adjacent to hot exposed metal that protrudes through insulation is even more troublesome than the difficulty elsewhere with pipe-covering jacketing. It has been found that the use of heat-resisting asbestos or glass cloth to replace canvas over the area near the hot metal has been effective in eliminating this trouble and the slight added expense is well justified.

Incidentally, large pipe bends are still covered with double-layer block construction, leaving an expansion joint packed with curly glass wool at both ends of each bend. In this design, the canvas is subject to excessive wrinkling and cracking and any possible improvement in technique of installation will be helpful in overcoming these difficulties.

Doubtless other improvements that can be made both in the quality of insulating materials and technique of application will make it possible to meet more of the exacting requirements in central-station and industrial steam power plants as well as in numerous other industries having extensive steam-piping installations.

Underground Steam Distribution Piping

The unique problems involved in the insulation of steam and hot-water pipes in underground ducts, which are particularly prevalent in heating-steam distribution systems, are also included in the broad subject of this paper. In one type of construction,[2] the pipe covering is wired in place, surrounded with a waterproof jacket, and swabbed at the joints with a waterproofing compound. The pipe is supported either on rollers in direct contact with the pipe or on saddles having lugs that extend through the insulation. In this type of construction, sealing of the outside surface of the covering is very difficult.

The problem of properly supporting the pipe and at the same time excluding flood water, which may enter the duct as a result of heavy rains, plugged sewers, or leaking water mains near-by, is serious because the insulation, when it becomes water-soaked, may disintegrate or rupture. In any case the insulating value of the covering is destroyed, steam condensation increases sharply, and the anticipated performance is not realized.

[2] Illustrated in the Handbook of the National District Heating Association, second edition, 1932, chapter 5, pages 149–241.

One phase of this problem is manifested by pitting of the pipe at the point of contact between the grounded metal supports and the pipe.

Inasmuch as flood water cannot be excluded from the covering when the common methods for supporting the pipe are used, the solution to this whole problem apparently lies in the development of either a rugged insulation that will carry the weight of the pipe on external supports without having its waterproofing membrane punctured or a design of construction in which the waterproofed insulated pipe is imbedded in concrete and in which the covering fits loosely enough to permit the pipe to expand and contract freely. In any event, the installation must not be so costly as to render its use uneconomical.

Piping for Fluids Below 50 F

It should not be lost sight of that considerable piping in power plants carries cold fluids. Insulation is applied on pipes carrying cold fluids for two purposes, first, to reduce to the economic minimum the absorption of heat by the fluid, and second, to maintain the temperature of the outside surface of the insulation at a level above the dew point of the surrounding atmosphere. Occasionally a problem arises when the outside surface of the insulation is not thoroughly sealed or when metal parts of valves or hangers protrude through the covering, making possible the entrance of atmospheric water vapor. If the dew point of the atmospheric water vapor is higher than the pipe temperature, the vapor will condense on the surface of the pipe. This condensation continues as long as these atmospheric conditions persist and, in the case of organic materials, rotting occurs in a surprisingly short time. Water vapor entering at a vulnerable point may migrate and become evident elsewhere, as happens in cases in which the flaw occurs on a vertical length of pipe having an elbow below it. The condensed water vapor trickles down the pipe and saturates the insulation on the lower side of the elbow.

The simplest means of preventing the entrance of atmospheric water vapor into the covering is to seal completely the outside surface with an impervious film or membrane. Painting the outside surface of the jacket is the simplest and least expensive form of surface sealing and is usually sufficient for straight sections of pipe. However, the painting job must be done thoroughly so that all the surface is covered prior to putting the equipment in service. The painting should be repeated at intervals of about two years to insure a thorough seal, as the paint usually cracks with age.

The most vulnerable points of the surface are those where the shape changes, as it does at elbows, tees, and valves, and where hangers enter. On these irregular portions of the structure, the proper thickness of felted sheet insulation is fitted in layers, tied in place, and each layer completely sealed. The assembly is usually covered with sheeting and the outside surface is painted. Manufacturers furnish detailed specifications for various types of construction for insulation on cold pipes, which provide for the use of sealing liquids and tapes, and instructions for their proper application. A typical construction, which

has been developed by an industrial user for temperatures as low as —250 F, is illustrated in Fig. 6. In this, and similar types of construction, the important feature is the isolation of the vulnerable portions of the insulation by means of a vapor barrier at the junction of the sectional covering and the felted sheet

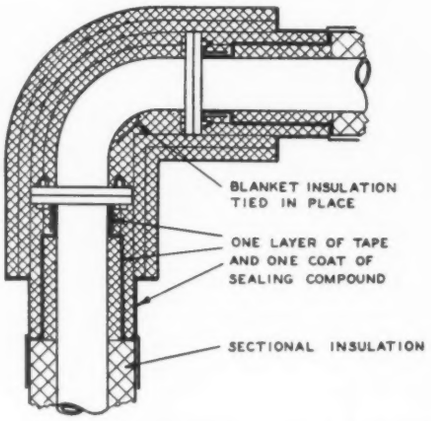


FIG. 6 SEALING OF INSULATION ON PIPES AT VERY LOW TEMPERATURES

insulation. This is accomplished by extending the vaporproof membrane from the outside surface of the sectional insulation across the face of the butt end and securing it onto the bare surface of the pipe. The great amount of labor and material necessary for such an elaborate assembly obviously makes it a costly one.

For installations on chilled water pipes, sealing has been accomplished recently at less cost by a technique for the use of a self-vulcanizing latex emulsion on cotton sheeting as a vapor barrier.

The precautions mentioned may appear to be elaborate but experience shows that in some instances insufficient attention has been given to the proper sealing of the insulation on cold pipes.

STEAM TURBINES

The selection of thermal insulation for steam turbines is a problem that presented few difficulties in the past when the operating steam temperatures were well within the use temperature limit for asbestos and magnesia products. However, the design of steam-generating equipment and turbines has advanced so rapidly in recent years and the use of higher steam temperatures has imposed such severe operating conditions on insulating materials that more and more attention has been directed toward developing and testing various types of thermal insulation for turbines.

Thermal insulation is applied to steam-turbine cylinders to prevent excessive heat loss, which would affect the efficiency of the turbine, and to make it possible to maintain a surface temperature on the planished-steel casing that will not burn the operators, discolor the paint, or render the surrounding atmosphere uncomfortable. The thermal efficiency of the material is, therefore, of considerable importance, particularly in those cases in which a limited clearance exists between the portions of the turbine shell and the outer steel casing.

It is obvious that the material must withstand the operating temperature without disintegration in order to avoid the expense of replacement of the material during the useful life of the equipment on which it is installed.

The selection of the kind of insulating material suitable for use on turbine cylinders is facilitated by a comparison of the practical temperature limit, installed density, and thermal conductivity of various commercially available kinds of block, plastic insulating cement, open-face flexible insulating blankets, and enclosed insulating pads.

Another important requisite is "cleanliness" of the material. Turbines are usually erected and periodically dismantled for repairs or overhauling in rooms containing machines in operation, and power-plant engineers rightly object to dusty conditions around this equipment. Because of this, the insulation used on turbines must be as dustless as possible.

Consideration must also be given to selecting a material that can be installed satisfactorily on the irregular contour of the average turbine cylinder in order to obtain a tight, securely fastened job. As steam turbines are periodically dismantled, overhauled, and reassembled, as often as every two or three years, convenience in handling and resistance to damage while men are working on the turbine are important matters.

Block insulation is difficult to fit to the contour of the turbine cylinder because of its rigidity and has the added disadvantage of being relatively dusty and messy to handle. When applied, the cracks must be pointed up and the surface protected with finishing cement.

Plastic insulating cement has grown in favor because it permits easy application over the irregularities in the turbine shell but it must be applied in layers, preferably less than 2 in. thick, covered with reinforcing netting secured to lugs on the casing, and troweled with a finishing cement—a procedure which requires several days to permit adequate drying of each layer on a cold surface. It is questionable whether admitting steam to the turbine to expedite drying of the plastic insulation is an acceptable operating practice due to the possibility of inducing unequal stresses in the bolts, flanges, and appendages. A greater thickness of this form of material would be required than of any other being considered because of its comparatively high thermal conductivity. This might be objectionable due to limited space available or to bulky appearance when completed.

The advantages of flexibility and low thermal conductivity

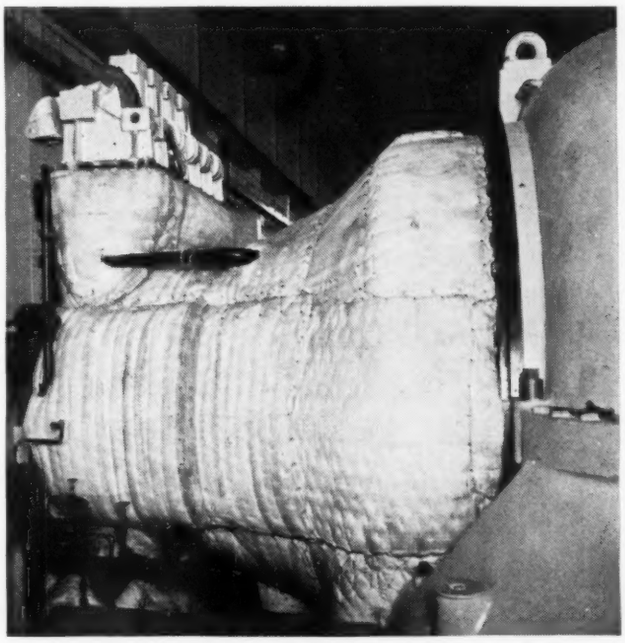


FIG. 7 INSTALLATION OF INSULATING PADS ON A 75,000-KW TURBINE

(Planished-steel casing yet to be installed.)

of reinforced open-face flexible insulating blankets are offset by the widespread objection to having around the turbine a loose wool that may become detached from its backing and to the difficulty of cutting the metal-mesh reinforcement to fit.

Among industrial and central-station power-plant engineers, the enclosed turbine pad seems to be the preferred type of insulation because of its ease of application, cleanliness, durability, and low thermal conductivity. Pads of this kind are composed of a plain or reinforced textile casing made from white or blue asbestos or glass fibers, enclosing a filler of white or brown asbestos fiber, loose, felted, or nodulated rock wool, or loose glass wool. As turbine pads are tailored to fit each job, the cost factor is a consideration, but this must be weighed against the advantages which are offered by this type of insulation. Fig. 7 shows a typical installation of insulating pads on the cylinder of a large turbine, and demonstrates the neatness, cleanliness, and ease of application that this form of insulation provides.

As a result of a comprehensive survey of heat insulation for turbine casings, which was recently undertaken by The Detroit Edison Company, the following conclusions were reached.

(*a*) Insulating pads, composed of a textile jacket enclosing a loose filler, appear to be the most desirable form of insulation for turbines.

(*b*) As determined by extensive field tests, there is one brand of glass-fabric pad with glass-wool filler that is preferred for temperatures up to 1050 F, and two brands of reinforced white asbestos pads with either mineral-wool or amosite asbestos fiber filler that are considered reasonably acceptable.

(*c*) From actual installations on various-sized turbines operating at different steam temperatures from 700 to 910 F, it was concluded that 50 F appears to be a reasonable temperature difference between the outside surface of the insulation and the ambient air. On many installations this temperature differential has been exceeded on large portions of the turbine insulation.

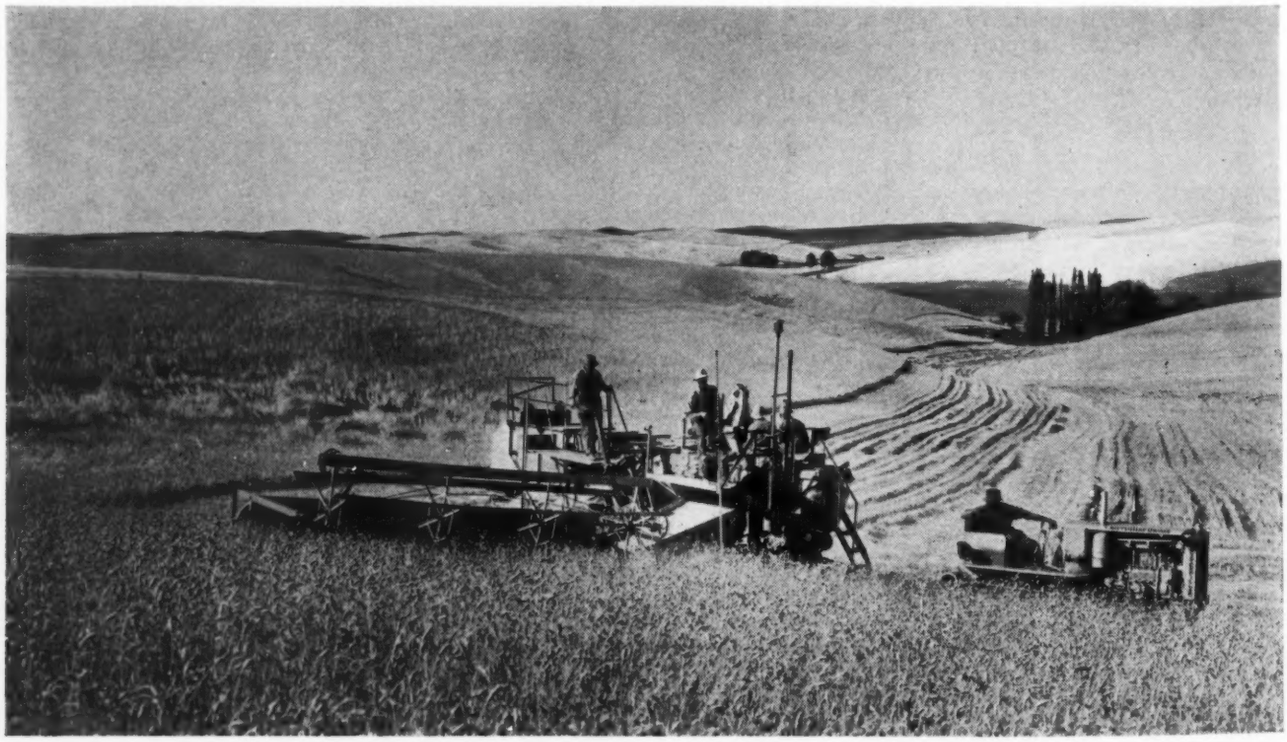
(*d*) Consideration should be given to insulating the exposed surface of the admission-valve stem guides on multiple-admission-valve type turbines.

(*e*) Incident to the study of the thermal insulation is the observation, both from tests and from actual installations, that iron or monel wire becomes exceedingly brittle when subjected to vibration at temperatures above 850 F. Specifications covering the installation of any type of insulation in which the lacing wire is looped around lugs on the turbine casing should provide for heat-resistant wire on those portions of the turbine casing above 850 F. Wire made from 18-8 stainless steel has proved satisfactory for this service.

It is apparent from this study that there are suitable materials commercially available to meet the conditions imposed in present-day high-temperature industrial and central-station power plants, but with a thought to the future, insulation manufacturers should anticipate the day when steam temperatures will exceed 1000 F as this is near the practical temperature limit for many insulating materials now available.

CONCLUSION

In this survey of heat-insulation problems in steam power plants, several important problems have been discussed, some definite recommendations have been made, and a few general conclusions reached. The examples cited have not been advanced as ideal ways of meeting these problems, but merely as illustrations of one company's current practice. In conclusion, it should be pointed out that users of thermal insulation should be willing to spend more for materials that will be conducive to lower cost of installation and, at the same time, will render better service by alleviating some of the difficulties now experienced with performance and maintenance.



HARVESTING WHEAT IN WASHINGTON, COVERING 40 ACRES IN TEN HOURS

(A.S.M.E. Fall Meeting will be held in Spokane, Wash., Sept. 3-6, 1940; for details of this Meeting and the Spokane Tour see page 495 of this issue.)

APPRENTICESHIP *in the* MACHINE-TOOL INDUSTRY

By ELMER H. NEFF

UPPER MONTCLAIR, N. J.

OF ALL the problems before the American public and especially the engineering public today, there is none more vital to our country than that of providing a supply of trained mechanics. This is especially true in the metal-working industries in which a considerable amount of time is required properly to train men. Since the business collapse in 1929 there has been a serious decrease in our capacity to take on manufacturing expansion or even to resume at the rate at which we were formerly proceeding. Many of our skilled mechanics have died, others have found permanent employment in other fields, and relatively little has been done in the training of new mechanics. In the trifling upsurge of business in 1936 and 1937, there was distinct difficulty in securing skilled mechanics. Therefore, I feel this matter of apprenticeship training is one to which all of us should lay our hand with vigor. If we should, in the near future, find ourselves or the world in general involved in a war, and we undertook to supply war materials on a large scale, we could not find men in sufficient quantity trained for that purpose. Therefore, I believe there is no more vital subject that could engage our attention than that of apprenticeship.

The first known artificer in brass and iron was Tubal Cain, who by his cunning handiwork beautified and adorned the Temple of King Solomon. Through the centuries since his time, there have come an increasing number of men likewise skilled in their crafts and also, as civilization increased and knowledge spread, an increasing number of crafts.

The machinist or machine worker in metal production has been an increasing factor in our modern life. Today probably in no other field is there so much and so vital development as is evidenced in the working of metal by machine tools. In fact, this increased production and efficiency, with its consequent cheapening of output may be the said to be the prime cause of the increased comforts and efficiencies of our modern life. The reduction in price of automobiles from $12,000 to a few hundred dollars, and the price of radio sets from $200 to less than $10 is due to the cheapened cost of these articles produced by increased efficiency of production by machine tools, especially automatic machinery.

AN APPRENTICESHIP AGREEMENT IN 1849

The training of machinists and machine workers in metal production is of the utmost importance. In our company this goes back nearly one hundred years. In fact, one of the members of the corporation of Brown & Sharpe Manufacturing Company, Lucian Sharpe, was first of all an apprentice to Joseph R. Brown. It is historically of interest that following an extended conversation between these two men, and prophesying the extreme care with which in all their subsequent lives they attempted to conduct their business so as to avoid misunderstandings, the following letter was written:

Providence, R. I.
April 30, 1849.

Mr. Joseph R. Brown.

Sir:

At your request I write down the agreement between us, which I understand to be as follows:

1st: That I am to work for you from the time I commence (September 12, 1848) to March 20th, 1853, making four years, six months, forty-eight days.

2nd: That for the first two years, six months, and eight days, I am to work for you as an apprentice and for the last two years as a journeyman.

3rd: That during my apprenticeship you are to teach me the clock and watch-making business and such other branches as you may pursue.

4th: That I am to receive for work in said term of apprenticeship, $50 per year and $2.50 per week for board; also a full set of watch tools as far as you are in the habit of manufacturing them. These I am to make during the said term of apprenticeship.

5th: That I am to have two weeks each year for recreation, all other time that I may be absent to be made up after my apprenticeship.

Yours truly, LUCIAN SHARPE.

This agreement was entered into more than ninety years ago. Subsequently, the apprentice became a partner and continued in the business to the day of his death. As time went on, it became necessary to vary and add to the course of instruction, especially as new machines were developed.

At present the company has 148 apprentices learning the following trades; the number being taught in each trade is given: machinist, 107; draftsman, 18; wood patternmaker, 8; molder, 11; coremaker, 2; metal patternmaker, 2; total, 148.

All the apprentices are in general charge of a superintendent of apprentices. Under him are instructors in each type of apprenticeship. These instructors are all practical skilled mechanics of long experience. One-half day, or four hours per week, is spent by each apprentice in the company schoolroom. In addition to these apprenticeships training in certain special courses, such as the operation of automatic screw machines, is offered. Company records do not accurately go back of 1861, but since that year, 1452 young men have completed apprenticeships. The large number of graduates form the backbone of the company's shop organization. However, we have contributed to other concerns in machine-tool or allied industries 10 presidents, 3 vice-presidents, 8 factory owners, 10 factory managers, 16 superintendents, 9 sales managers, 14 chief engineers, 13 general foremen, 4 master mechanics, and many trained workers.

In the company's factory, apprentice graduates are filling all sorts of positions from that of the highest officials to that of workmen. They are employed outside the factory as machine demonstrators teaching users how to get the best results, and they are distributed in all of our branch offices as salesmen.

It is not my intention to go into the details of any of the apprentice courses outside of that for machinists, but all of the others are laid out with careful regard to complete technical detail so as to provide a thorough training in whatever the apprenticeship named may be. However, the length of time

Contributed by the Committee on Education and Training for the Industries and presented at the 60th Annual Meeting, Philadelphia, Pa., Dec. 4–8, 1939, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

in weeks of these apprenticeships are as follows: drafting, 150; wood patternmaking, 200; metal patternmaking, 150; molding, 150; and coremaking, 75.

MACHINIST'S APPRENTICESHIP

To be eligible for the machinist's apprenticeship, a young man must be not less than sixteen or more than eighteen years of age, with the exception that high-school graduates are eligible at nineteen years of age. Preference is given to applicants who have had at least two years of senior high school, or its equivalent in a trade school. The applicant, preferably accompanied by his father, is first given a careful interview by the superintendent of apprentices for the purpose of making some mental reading of his character and personality and determining whether he really wants to take up the course he has asked for. After this interview, he is given several tests, including a thorough physical examination.

All accepted applicants for apprenticeship are taken on trial for three months. This trial period is to enable the company to determine whether it has correctly judged the boy's capabilities, and for him to decide whether he has started on the right training course. If the factory, at the end of the trial period, finds the beginner satisfactory, and he wishes to go on with his apprenticeship, he and his parent or guardian and an official of the company sign an agreement faithfully to carry out the terms of the apprenticeship for the remainder of the specified time. When the agreement is signed, the apprentice pays an entrance fee of $50. During the trial period he is loaned a set of tools. If he goes ahead at the end of the trial period, he must provide himself with a set of tools and these he can buy on the installment plan. At the end of a satisfactory apprenticeship, the graduate is given a diploma and a bonus of $150.

The apprentice is paid for every hour he works in the shop and in the classrooms. As an added incentive to diligence and application, he may receive more than the normal pay if his work is marked by his shop instructors and foreman as "excellent rating." Table 1 lists the kinds of shopwork and the time spent on each in the machinist's apprenticeship.

TABLE 1 KINDS OF SHOPWORK INCLUDED IN MACHINIST'S APPRENTICESHIP

	Weeks		Weeks
Engine lathes	24	Production grinding	12
Turret lathes	8	Operating automatic screw machines	2
Drills	6	Operating hand screw machines	4
Milling	24	Planing	12
Scraping	4	Gear cutting	8
Thread milling	2	General machinist work	16
Assembly and erection of milling machines	10	Repairs	18
Assembly and erection of grinding machines	10	Toolmaking	20
Assembly and erection of screw machines	10	Miscellaneous work	10
		Total	200

Details of shop instruction and practice which constitute the machinist apprentice's training may be obtained from The Brown & Sharpe Mfg. Co. Concurrently with shop instruction and practice, four hours a week are devoted to classroom work.

CLASSROOM WORK

An instructor in the classroom devotes full time to instructing classes of apprentice machinists. For one-half day of each week of the 200 weeks the topics listed in Table 2 are studied for the periods indicated.

RECREATION AND HEALTH

Our apprentices at present are from thirteen states. For the accommodation of those who come from other places than Providence and cannot, therefore, live at home, we have equipped two buildings as dormitories that will accommodate 63 apprentices. These buildings were formerly large private residences and have been transformed for our purposes and provided with all the latest conveniences, including shower baths and amusement rooms. Each building has a matron and a corps of necessary helpers.

TABLE 2 TOPICS STUDIED IN THE CLASSROOM

	Weeks		Weeks
Blueprint reading	8	Spiral milling and cam milling	8
Decimals and fractions	3	Indexing	7
Discounts and percentage	3	Cutting speeds and feeds	10
Ratio and proportion	2	Mechanics	12
Powers and roots	1	Physics as applied to mechanisms	12
Linear and angular measure	2	Mechanical drawing	24
Volumes and weights	2	Special problems	16
Geometry	4	Miscellaneous, including metric measure, tapers, cutting oils, grinding speeds, pulley speeds, circular form tools	9
Practical trigonometry	24		
Logarithms	4		
Threads, thread cutting, and thread milling	14		
Gearing and hobs	26		
Continued fractions and logarithms of gear ratios	3		
Screw-machine cams	6		200

The health of all apprentices is carefully looked after with particular attention to the residents in our dormitories because they are away from home. The physician from our dispensary gives medical attention to any cases of illness, but if the boys are confined to their rooms, other medical attention is secured immediately.

Considerable attention has been given to organizing the boys and providing them with means of normal healthful amusement. In the rear of the dormitories there are fine clay tennis courts which can be used not only by the boys living in the dormitories but by other apprentices as well. A tennis tournament is part of the annual program. Also behind the apprenticeship building is a court for horseshoe pitching. There is a Brown & Sharpe Soft Ball League in which the apprentice teams compete with teams from other departments of our works. The apprentice department has a team in the Brown & Sharpe bowling league. In summer swimming is a popular sport and the boys can readily get to beaches near the city.

As an added mental interest the apprentice department publishes a monthly magazine called the *Techno-Scope* which has an editorial force chosen by and from the apprentices. The boys are encouraged to write articles or bring news items, furnish sketches, or tell of trips they have taken during their vacation. A write-up is given in the *Techno-Scope* for each new entrant to any of our apprentice courses which serves as an introduction to the apprentice force. All of these features connote an added interest in the work and create an esprit de corps that lasts throughout the lives of the apprentices.

CONCLUSION

I recommend that you do not put your apprenticeship system in charge of a school teacher unless he is also a practical mechanic. The instruction in these matters should be in the hands of practical skilled mechanics with a long training and with some capacity for teaching others. The most important qualification for the instructor, however, is his own knowledge of his subject. He must be a man of good judgment, capable of reading character, and possessed of tact and patience.

In conclusion, I must again urge the extreme importance to our country of this matter of training mechanics. It will reduce our unemployment most materially, it will build up the industries in which we are engaged, and it will make for our cities, for our states, and for our national government a stabilizing element whose importance cannot be overrated.

READING CLUBS *for* ENGINEERS

By WALTER H. KAISER

TECHNICAL LIBRARY, TENNESSEE VALLEY AUTHORITY

LEADERS in the engineering profession are saying today that the engineer should become more socially minded; that he should more fully understand the social consequences of his engineering decisions. They are saying, further, that the answers to technical problems are but one part of the equation of the good society. The other and heretofore scarcely considered part is the effect of technology on man. And this is, indeed, a bewildering problem. For in the social sciences he finds no inviolable axioms, only general statements and observations; few rational solutions, but most often compromises and adjustments; he is confronted with the uncertainties and imponderables of life.

How is the engineer to achieve an increased awareness and understanding of his relation to the problems of society? The question is being faced squarely by the profession's leaders. However desirable it is for the engineer to have a sound knowledge of the social sciences, the fact is that the engineering curriculum is so filled with fundamental courses that insufficient time remains for this necessary, if secondary, information. It is the opinion of W. E. Wickenden, who has given much thought to this question, that "The most serious deficiency in engineering education is not so much in matter taught or omitted in college as in allowing the orderly process of education to stop, where it often does, at graduation. To require all engineering students to remain five or six years in college would be an arbitrary solution, but an artificially superficial one. . . . . It seems that the most urgent educational task now before the engineering profession is to create a direct and effective program of continuation education for the first five years after graduation from college."

The Engineers' Council for Professional Development, representing seven national engineering bodies, has a constructive program to promote the full personal and professional growth of the engineer. This paper will concern itself with one part of this program, namely, the reading plan for junior engineers.

In the second annual report of the Engineers' Council for Professional Development, 1934, appears a reading list of books for junior engineers. The Council explains the objectives of the list in these words:

> Two of the most important attributes the successful engineer must possess are first, the ability to deal with men and affairs and second, the ability to read and absorb the written experience of others. These abilities are seldom found fully developed in any man. Generally, they must be developed by the individual himself and usually after formal education is completed.
>
> The Reading List given here, based upon recommendations by a number of eminent men, many of them distinguished engineers, is presented especially for the junior engineer who is desirous of broadening himself and developing a full professional life.... It is expected that these subjects will provide the basic framework on which the nontechnical culture of the engineer will be built.

It may be added that this list, as distinguished from the Council's excellent lists on technical subjects, recommends books aimed primarily at cultural growth and professional growth only in the fields closely but definitely related to success in an engineering career. These related fields include personnel management, economics, psychology, and industrial organization.

Briefly, the reading plan of the Council is this: Some 150 titles in natural science, philosophy, economics and sociology, psychology, business and industrial management, belles lettres, history, biography, travel, and fine arts were carefully selected by eminent engineers. Four titles should be read each year for a period of five years, the selection including at least one title in each classification.

READING PLAN ADOPTED BY TVA AT CHATTANOOGA

To place the recommendations of this admirable plan before large numbers of engineers and to organize reading clubs, the Training Division and Technical Library of the Tennessee Valley Authority in Chattanooga, Tenn., worked out the following plan: N. W. Dougherty, assistant dean of the College of Engineering, University of Tennessee, was secured to discuss present trends in engineering education and to point out the rewards for the engineer who continues his education in fields not covered in the curricula of engineering schools. The second step was to check the titles included in the reading list of the Council for availability in the Chattanooga Public Library and to obtain promise of cooperation from the librarian in supplying the books. The third step was to call meetings of representative engineers from various departments in order to explain the plan and to get their criticisms and approval. The fourth step was the circulation of the mimeographed list of available books by these department representatives so that the engineers might indicate their selections. The fifth and final step was the grouping of those interested into reading clubs of twelve members each. An attempt was made to give every engineer as many choices as possible, the books being issued for a period of one month.

Two optional plans were offered: The first provided for the free circulation of books, the second for purchase. In the latter plan the cost of books was assessed pro rata, and each member received one book as his personal property after it had been read by others in the group. The response was surprising and encouraging. Of approximately two hundred and fifty civil, electrical, and mechanical engineers who were informed of the opportunity, ninety-nine joined the free circulation plan, and thirteen the purchase plan. It is of interest to note that the reading groups were composed of both supervisors and supervised, both older and younger engineers, ranging in position from project engineer to draftsman.

Titles which were preferred with the greatest frequency were:

Adams, J. T.	Epic of America
Adams, J.	Everyman's Psychology
Beard	Whither Mankind
Browne	This Believing World
Chase	Economy of Abundance
Chase	Rich Land; Poor Land
Conrad	Lord Jim
Durant	Story of Philosophy
Gardner	Understanding the Arts
Gow	Foundations for Human Engineering
Harding	Business Administration for Engineers
Jeans	Universe Around Us
Lippman	Preface to Morals
Ludwig	Abraham Lincoln
Martin	Meaning of a Liberal Education

Maugham	Of Human Bondage
Melville	Moby Dick
Robinson	Mind in the Making
Schell	Technique of Executive Control
Smith	Psychology for Executives
Tead	Art of Leadership
Thomson	Modern Science
Wells	Outline of History
Wilson	Great Men of Science

WHAT ENGINEERS THOUGHT OF THE READING-CLUB PLAN

The operation of the reading clubs began in April, 1938, and ended May, 1939. Upon their completion, a questionnaire was sent to each member still located in the Chattanooga area, soliciting his reaction and comments on the reading plan. Eighty-six engineers filled out the questionnaire, and it is on these returns that the figures in Table 1 are based. The questions and results are tabulated in Table 1.

TABLE 1 QUESTIONS AND ANSWERS ON READING-CLUB PLAN

Question	Composite total	Percentage of composite total
1 During the year you received 12 books.		
(*a*) How many did you read completely?...	398	38.4
(*b*) How many did you read partially?.....	339	32.7
(*c*) How many did you fail to read?.....	300	28.9
2 The reason, or reasons, why you read some partially or not at all were:		
(*a*) Lack of interest in subject matter.....	63	39.4
(*b*) Lack of time.....	76	47.5
(*c*) Style of writing.....	11	6.8
(*d*) Previous reading.....	10	6.3
3 To what extent did this reading program contribute to your cultural or professional growth?		
(*a*) Considerable.....	15	18.3
(*b*) Some.....	51	62.2
(*c*) Very little.....	16	19.5
4 What is your general reaction to the reading club?		
(*a*) Favorable.....	75	87.2
(*b*) Indifferent.....	11	12.8
(*c*) Unfavorable.....	...	...
5 What suggestions have you to make to increase the value of the reading program? If more space is needed, write on back of this sheet.		

A few of the salient points brought out by the returns from this questionnaire which might be stressed are:

1 Over seventy-one per cent of the books were read completely or partially.

2 Of the books read partially or not at all, lack of time was the greatest obstacle to reading, followed closely by lack of interest in the subject matter of the books.

3 Eighty per cent of the engineers believe the reading contributed to their cultural or professional growth.

4 Eighty-seven per cent were favorable to the reading-club plan.

5 Eighty-three per cent of the members who are potential joiners of new reading groups have indicated their intention to join the clubs beginning in October, 1939. (It must be remembered that during the year a number of employees resigned or were transferred to work taking them from this area.)[1]

[1] In 1939–1940 the reading clubs had a total membership of 190. However, employees other than engineers were included. Since the percentage of renewal memberships is perhaps the best measure of the program's popularity, it is interesting to note the following fact: Eighty per cent of the engineers who were participants in 1938–1939 rejoined the clubs in 1939–1940. Only three per cent failed to rejoin after indicating their intention to do so. There may have been reasons other than lack of interest which prompted this change of intention.

Some of the comments on the reading clubs are interesting, and reveal a surprisingly broad field of interests.

An electrical engineer says, "Include such subjects as botany, chemistry, story of inventions, biographies, petrology, and aeronautics."

Another remarks, "Give us variety in modern fact and fiction."

A cartographer states, "H. G. Wells's Outline of History is, in my humble opinion, a book with some misleading statements and prejudices."

One civil engineer believes "interest would be added by including more biography and travel."

Several engineers said, "Give us more recent books."

An unusual comment reads, "Include some books in which historical events and economics are dealt with from a more liberal viewpoint."

Most of those who commented were in favor of continuing the plan as it is. Many more had no suggestions at all and signed up for future reading clubs.

The main disadvantages of the reading-club plan are:

1 It is difficult to give every member all or even a good percentage of his first choices. Reading interests are too diverse to be included in a selection of twelve books.

2 Supply of a sufficient number of readable and popular books may be limited. Duplication of the better titles for inclusion on several clubs will offset this handicap. We have found up to dateness to be an important factor for selection of books. This list includes only the books written before 1934. Since that time many worth-while and readable books have been published which should be on the reading lists.

The major advantages are:

1 The reading lists carry weight because the books are carefully selected by successful engineers and engineering educators to achieve the reading objectives of the Council.

2 The inertia which possesses us all and discourages reading is partly overcome by placing a book in a potential reader's hands. One important discovery of reading habits is that people read what is conveniently at hand.

3 The members of a club "sell" each other on books which they might not normally read. The books stimulate profitable and pleasant discussion.

4 After one year of operation of the reading clubs, our results show that each member of a club read completely between four and five books and read partially about four titles from this carefully selected list. This is, indeed, a gratifying result, being appreciably better than the four books a year recommended by the Council.

Where large numbers of engineers are employed by one organization, the formation of reading clubs is feasible and successful. A plan for the circulation of books can easily be worked out. In communities where engineers are scattered but do come together at engineers' clubs, it may be possible to arrange with the local public library to supply the books recommended by the Engineers' Council for Professional Development and to organize reading clubs. If the local groups do not wish to form reading clubs, someone in the society should call the members' attention to this valuable part of the Council's program and see to it that an adequate number of the books are available at the public library or elsewhere in the community. Some of the local groups may even consider buying a number of the titles for the club's library.

Our limited experience in the Tennessee Valley Authority indicates that the engineer will take advantage of an opportunity that promises to give him a mature and better understanding of human relations as they are affected by the advance of science and technology.

STATISTICAL METHOD[1]

By LOUIS C. YOUNG

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BASED upon a series of four lectures delivered before the Graduate School of the Department of Agriculture, Dr. Shewhart's book[2] is concerned with the rationale of applied statistical methods. The discussion is centered primarily upon the theoretical background of statistical methods in mass production, with further attention being given to the interpretation of the results of physical research. Inasmuch as it relates the basic mathematical principles of statistics to the results observed in the laboratory and in the plant, the book should be of interest to both engineers and to research workers.

In chapter 1 Dr. Shewhart confines his discussion to the various interpretations placed upon the meaning of statistical control. The production engineer, he points out, may conceive of control as a conventional mode of operation, whereas a large-scale consumer is likely to associate the term with a specific pattern of quality measurements on the finished product. The author classifies the various meanings into three major divisions: the state of statistical control, the operation, and the judgment. The first of these is considered in its relationship to measurements made upon a manufactured product; and the difficulty of defining a state of statistical control is illustrated. Assume, for example, that a finite series of measurements

$$X_1, X_2, \ldots\ldots X_n, X_{n+1}, \ldots\ldots\ldots X_{n+j}$$

is obtained under uncontrolled conditions. Then an infinite series of approximately similar values can be conceived, arising from a state of statistical control, and containing a finite portion of $n + j$ terms identical in order and magnitude to those observed in practice. The plausibility of such a conception is increased upon consideration of the large numbers of finite series which may be formed from an infinite series constituting a statistical population. Following this line of reasoning, then, it may be seen that any finite series of measurements apparently could have been produced under controlled conditions, even though the actual conditions under which it was produced were far from controlled. The practical significance of the foregoing may be more readily grasped by considering a simpler problem of the same nature, in which it will be assumed that a coin is tossed a large number of times. During the course of such an experiment, it is quite possible that a head might come up, say, in twenty consecutive tosses. Any person claiming to have tossed a coin only twenty times upon a single occasion, obtaining a head each time, might be suspected of having performed some nonrandom operation in tossing the coin, yet the event is quite possible. A criterion of control based upon a comparison of the observed sequence with a portion of an infinite sequence, therefore, would always show that the observed sequence could have been obtained under controlled conditions. Needless to say, the same argument can also be applied in the opposite direction, assuming an infinite sequence of nonrandom values, and an observed sequence of values produced under controlled conditions. In this event, application of such a criterion of comparison would always show that the observed sequence could have been obtained under uncontrolled conditions. The value of the criterion from a practical viewpoint would obviously be nil.

Another possible criterion of the degree of control influencing data observed in the plant is a comparison of the frequency distribution actually obtained with a generalized, theoretical distribution which may be expressed in the form

$$dp = f(X)dX$$

Dr. Shewhart proceeds to indicate the disadvantages of such a test of control. The most obvious shortcoming, he shows, is that the comparison ignores the order in which the measurements were observed. Furthermore, any mathematical function so expressed represents the limiting case of a controlled, infinite sequence of observations, not a finite portion such as a series of observational data. As a final argument against that type of criterion, it is pointed out that there has not yet been discovered any single, generalized function which might serve to characterize all random series.

Having demonstrated the present impossibility of obtaining a unique, mathematical description of a statistical state of control, the author advances a blanket specification of the operation of control. In describing broadly the manner in which data should be investigated and classified, Dr. Shewhart draws upon his wide experience in emphasizing the importance of retaining all pertinent facts. The order in which a sequence of measurements is made, for instance, may be the chief clue to the existence of a major cause of variation. An example given in support of the statement serves as an excellent illustration; following is a series of nine determinations of the density of oxygen, listed in the order in which they were made:

Order of determination	Density of oxygen
1	1.42900
2	1.42894
3	1.42896
4	1.42892
5	1.42895
6	1.42891
7	1.42892
8	1.42894
9	1.42895

There is no readily apparent lack of control which would lead the investigator to believe that conditions had changed during the course of the experiment. Had the determinations been made in the following order, however, the presence of a trend in the observations might leave the constancy of experimental conditions open to question:

Order of determination	Density of oxygen
1	1.42891
2	1.42892
3	1.42892
4	1.42894
5	1.42894
6	1.42895
7	1.42895
8	1.42896
9	1.42900

The third interpretation to be placed upon the meaning of

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "Statistical Method From the Viewpoint of Quality Control," by W. A. Shewhart. Edited by W. E. Deming. Graduate School, Department of Agriculture, Washington, D. C., 1939, 155 pp., $2.50.

statistical control is that of a group of judgments, based upon evidence created in the operational stage of control. The series of judgments, in the manner of criteria, determines the degree of control attained during the operation, whether the latter is represented by the manufacturing process or by the physical experiment. In reviewing the three phases of control, the author compares the state, the operation, and the judgment of control with the three major components of mass production, specification, production, and inspection. Historically, the components constituted a group operation for each article produced, specification being followed in turn by production and inspection. Inspection served only the purpose of determining whether the initial specification had been fulfilled. Only in recent years have the three phases of control become the interrelated parts of a cycle, in which specification is dependent upon previous judgment of control to the same extent as the judgment is dependent upon the operation of production.

In his second chapter, Dr. Shewhart introduces the problem of the method to be used in establishing limits of variability. Consider the optimum case of control, as represented by a group of numbered chips mixed in a bowl and drawn at random, each chip being replaced in the bowl before another is drawn. If the number of chips with each type of marking is known, then two limits can be chosen arbitrarily, so that the numbers on a fraction p of the chips will be known to lie between those limits. When the chips are drawn from the bowl under the conditions described, therefore, there will be a fraction p' of the observed chips having numbers lying between the specified limits; furthermore, only the laws of chance will cause p' to deviate from the fraction p. By postulation, as more and more chips are drawn with replacement, the value of p' will tend to approach p as a limit. The same will hold true even if the markings on the chips in the bowl are not known. This situation corresponds more closely to the practical situation in which observations are obtained under controlled conditions. The parameters of the chips in the bowl—such as the mean and the standard deviation—are unknown, but are approached by the corresponding characteristics of the distribution of chips drawn from the bowl as the drawing proceeds. It is readily seen that knowledge of the markings on the chips in the bowl is increased by drawing a greater number of them. In either of the two cases considered, the source of the observations is said to be homogeneous.

A different condition is encountered when the observed series of measurements does not originate in a state of control. If important causes of variation enter the production process or the physical experiment, the observed measurements may no longer be viewed as numbers drawn from a single bowl. Every time that the conditions of experiment or production change, the measurements must be viewed as being drawn from a different bowl, containing a separate set of numbered chips. If limits are based upon the first few observations obtained under such circumstances, the fraction p' of future values lying between those limits will not approach a limiting value; no constant limiting value exists. The source of the observations possesses changing parameters and, therefore, the estimates of those parameters—based upon the sampled observations—will remain inconstant. If information is available upon drawing a chip to show whether it came from the same bowl as the previously drawn chip, then a sequence of observations can be divided into groups containing values which came from the same source. The practical equivalent of this is usually described by the statement that conditions remained constant during the determination of each group of measurements (or during the manufacture of a group of products on which measurements were made later). Dr. Shewhart has applied the descriptive phrase "rational subgrouping" to this operation of classification, and furnishes the following example of a nonhomogeneous group of measurements.

The data in Table 1, representing 5000 measurements of the tensile strength of malleable iron castings, were based upon material from seventeen different sources. Although each source in itself may have represented a state of statistical control, the difference between the several sources is quite evident.

TABLE 1

Source no.	Tensile strength, lb per sq in. Maximum	Minimum	Average
1	59,000	45,000	54,000
2	58,500	53,000	56,250
3	56,880	50,000	52,460
4	55,850	47,850	52,890
5	62,140	54,400	57,920
6	62,860	52,150	56,350
7	56,000	50,000	53,000
8	58,000	50,000	55,000
9	61,300	49,000	55,000
10	59,800	50,000	53,970
11	60,000	46,600	52,670
12	58,000	50,000	53,000
13	62,000	51,000	53,000
14	56,640	45,500	51,170
15	61,500	45,000	53,710
16	58,000	50,500	55,500
17	56,160	50,480	52,830

There would be little justification, therefore, for grouping the separate sets of observations together. The same reasoning may be applied to consecutive groups of data taken under different conditions in the same plant. The ability to predict the limits within which future measurements will lie is reduced if major causes of variation are ignored. If such a cause of variation can either be eliminated or accounted for in the prediction (as in predicting the expected tensile strength of iron, given information as to its source) then the validity of the prediction is decidedly increased.

In further discussion of the methods of establishing tolerance limits, the "Student" distribution is introduced, and its use in setting tolerance limits for small samples is contrasted with the procedure more commonly employed. In the latter procedure, the means of a certain proportion of samples are expected to lie within constant limits placed about a theoretical goal. In the case of the distribution mentioned, a theoretical goal is expected to fall—for a certain proportion of samples—within limits placed about the mean of each sample, the limits themselves being dependent only upon the individual sample. As the author demonstates, however, the use of the "Student" distribution gives predictions of questionable validity when the observational data are distributed in a fashion which is far from normal. A related topic is the unsound usage of standardized tolerance limits for variables (such as the standard deviations of small samples) which are known to follow nonnormal laws of distribution. From the point of view of maximum validity of prediction, the form of the distribution should be investigated, using a large number of observations, and those limits should be applied which are most appropriate to the particular type of distribution.

Dr. Shewhart's treatment of accuracy and precision is from a common-sense viewpoint, and is primarily concerned with constant observational error due to the observer and the method of determination. Chief interest is centered in the problems of scientific research; a typical example of those problems is presented in the form of a historical series of determinations of the velocity of light. The absurdity is revealed of any effort to average data obtained from significantly different sources in an endeavor to estimate the true value of the speed of light with optimum accuracy.

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers in Previous Issues

Mechanical Problems in British Transportation

FOLLOWING are abstracts of written discussions received by The Institution of Mechanical Engineers (Great Britain) on three of the four British papers which were to have been presented at the British American Engineering Congress, scheduled to take place in New York City, Sept. 4–8, 1939, but canceled owing to the outbreak of war. Abstracts of all the British papers were published in MECHANICAL ENGINEERING, December, 1939.

Transatlantic Air Transport

A. H. R. FEDDEN.[1] The writer concurs with the contents of the paper,[2] especially with the remarks concerning the desirability of Diesel engines. The advent of 100-octane fuel has given the gasoline engine an enormous advantage, but there are still many reasons why the Diesel engine deserves serious consideration for long-range aircraft. Besides the advantages put forward in the paper, there are other gains obtainable for high-altitude flying, namely:

1 It is likely that the development of an exhaust turboblower could be greatly simplified for a Diesel engine due to the lower exhaust temperature.

2 There is an absence of icing hazards.

3 Intercoolers are unnecessary due to the ability of the Diesel engine to run with high induction temperatures. As the intake air need not be heated it is possible that this would help to balance the blower temperature rise at high altitudes. The loss in volumetric efficiency would also be counterbalanced by the reduced installation drag.

4 Pilots' controls are simplified.

5 The Diesel power plant and fuel load are lighter than in the case of the corresponding gasoline-engined aircraft for flights exceeding 10 hours.

No mention is made of refueling in the air when take-off conditions are discussed at the beginning of the paper. It would appear from reports that Imperial Airways has obtained a high degree of efficiency with this method, but whether it could be employed in the case of fuel oil remains to be seen.

N. A. V. PIERCY.[3] The writer disagrees with one of the main conclusions, namely, that 12,000 ft is a suitable altitude for transatlantic air service. His own view (shared, he believed, by others) is that double this altitude might soon become advisable. It is agreed that knowledge of atmospheric conditions high above mid-ocean is poor, and would hardly improve until a ship has been chartered for meteorological observations on the direct or northern Atlantic route, as has been done already on the southern route. Nevertheless, it might well be anticipated that at some 25,000 ft aircraft would fly over most of the bad weather. Increased speed would ensue, and, though effective only during the easterly journey, would still confer a benefit in view of the change in time between New York and London. But the overwhelming advantage is in respect of comfort and safety, particularly from ice accretion.

Another question on which the author's views would be most valuable relate to the seaworthiness of flying boats. Repeating his words without suggestion, do present-day hulls give much more than "a feeling of additional security" against forced landings in mid-ocean?

A. GOUGE.[4] The author notes that Dr. Piercy considers that an operating altitude of 25,000 ft might be advisable. However, before any decision on this point can finally be made, operating experience would be necessary. It is agreed that the comfort of passengers would be improved by flight at high altitudes, due to the more uniform weather conditions, but it is by no means certain that the disadvantages of living in an enclosed cabin would not more than outweigh the comfort to be obtained, since flying across the Atlantic takes 12 or more hours.

There can be no doubt that the ability of the flying boat to ride out bad weather at sea is considerably greater than that of the corresponding airplane. The chances of a flying boat surviving after a forced landing are, therefore, much better. Of how much value this is, it is difficult to estimate.

It is interesting to note from Dr. Fedden's remarks that the Diesel engine is still being very thoroughly considered in England, and that the position regarding development is better than the author thought it was.

Any reference in the paper to refueling in the air is omitted because at the time of preparing the paper the first of these flights had yet to be made. There is no doubt that refueling in the air helps either the flying boat or airplane to carry a heavier pay load, but over the distance involved in crossing the Atlantic it would only be a matter of time before such adventitious methods could be dispensed with.

Motor Transport

A. W. HUBBLE.[5] There is little one could add to the paper,[6] which is fully representative of British practice. The writer is especially interested in the author's remarks on direct and indirect injection in Diesel engines since his company has manufactured and marketed Diesel engines for transport service as far back as March, 1931. They commenced with direct injection, but today production also includes indirect-injection engines. Both are satisfactory, as far as efficiency and economy are concerned but, although the direct-injection unit has the better fuel consumption, the indirect scores in respect of cleanliness.

V. W. PILKINGTON.[7] Just as the author states, much that is good has resulted from the regulations covering de-

[1] Chief Engineer, Bristol Airplane Co., Ltd., Bristol, England.

[2] "Transatlantic Air Transport With Particular Reference to Flying Boats," by A. Gouge, Proceedings of the I.M.E., vol. 142, 1939; and (abstract) MECHANICAL ENGINEERING, December, 1939, pp. 876–878.

[3] Temple, England.

[4] General Manager, Short Bros., Ltd., Rochester and Bedford, England.

[5] Crossley Motors, Ltd., Gorton, Manchester, England.

[6] "Motor Transport," by E. C. Ottaway, Proceedings of the I.M.E., vol. 142, 1939; and (abstract) MECHANICAL ENGINEERING, December, 1939, pp. 878–880.

[7] Mechanical Engineer, Lytham, St. Anne's, Lancashire, England.

sign and construction of both passenger- and goods-carrying vehicles, and, undoubtedly, the standard of roadworthiness of all public-service vehicles is of a very high order. The difficulties arise due to anomalies both in classification and taxation. In an industry which is progressive, the framing of legal restrictions designed to meet the needs of the hour, might be quickly proved obsolete by technical advancement. It is therefore of the greatest importance that revision of restrictive legislation should be made from time to time, and anomalies removed which might otherwise retard the progress and competitive ability of the industry.

E. C. OTTAWAY.[8] The author is interested to read Mr. Hubble's remarks concerning the relative merits of the direct- and indirect-injection engine. He agrees that the direct-injection engine has been at a disadvantage in the past in regard to the cleanliness of exhaust, although it was brought out in the paper that this disadvantage had been to a large extent eliminated by more recent developments. The more modern types of direct-injection engine are, in the author's opinion, suitable for use in congested areas.

Mr. Pilkington has laid stress on certain aspects and anomalies in the Regulations. There is no doubt that the Regulations are, in many respects, anomalous, and particularly in those to which reference was made in the paper.

Lightweight Passenger Rolling Stock

MAJOR P. J. COWAN.[9] The introduction to the paper[10] might possibly give rise to a misconception in the minds of some readers. While the statements made are strictly correct, especially as the paper is understood to apply to London, Midland & Scottish Railway practice, it should be realized that the radical departure in design, which Mr. Stanier dated 1932, really occurred in Great Britain on the Metropolitan District Railway in 1920. In that year, W. Agnew, the subway company's chief mechanical engineer, designed at Ealing, and put into commission in 1921, 50-ft truck rolling stock embodying what were then quite new features to the country.

C. E. R. SHERRINGTON.[11] The writer wishes to draw attention to the essential differences existing on British and American railways with regard to car construction. Though the United States is nearly forty times the size of Great Britain, and the railway mileage, first track, ten times as great, the number of passenger cars in service on the four British railways was 42,575, as against only 40,259 on the class-1 railroads of the United States, plus about 8000 Pullman cars. During the period 1930–1937, inclusive, no less than 11,024 passenger-carrying vehicles were placed in service by the British lines (in addition to 4000 other cars for working on passenger trains) as against 2778 in the United States.

Since the British railways construct the great majority of their passenger cars in their own six large construction shops, the opportunity for standardization has been extensive and, with the large number constructed annually, expenditure could be incurred on new machinery which, spread over the large output, could pay for itself reasonably quickly.

Reference is made in the paper to lowering of weight by reducing the wheel diameter. It would be of interest to know whether, where such a policy has been adopted, its effect on track maintenance costs has been noticeable.

W. A. STANIER.[12] The author is very glad that Major Cowan has drawn attention to the work by Mr. Agnew on the Metropolitan District Railway in connection with this form of rolling-stock construction.

[8] Technical Officer, London Passenger Transport Board, London, England.

[9] Surbiton, Surrey, England.

[10] "Lightweight Passenger Rolling Stock," by William A. Stanier, Proceedings of the I.M.E., vol. 142, 1939; and (abstract) MECHANICAL ENGINEERING, December, 1939, pp. 880–882.

[11] Railway Research Service, London, England.

[12] Chief Mechanical and Electrical Engineer, London, Midland & Scottish Railway, London, England.

Unionization of Engineers[13]

TO THE EDITOR:

Not being a past-president of the A.S.M.E., or a ranking officer, or the president or chief engineer of some corporation, or for that matter, even a member of the Society, I cannot presume to speak with the authority of most of the contributors to the discussion of unionization of engineers current in the Society journal.

On the other hand, being an employee engineer of some nine years' industrial experience, I feel that I am far better qualified to speak for the vast majority of engineers to whom the question of organization is a problem, many of whom, like myself have carefully considered the advantages to be gained at a cost of ten, fifteen, or twenty dollars per year for A.S.M.E. dues, and have decided in favor of shoes, or rent, or books, or study.

The majority of the discussion has been on the high plane of "professionalism" one would expect from the A.S.M.E., a plane so high that it is difficult to discern any of the jumbled details of the real problem, far below. However, I have followed with considerable interest the opinions of Mr. Snaith, Mr. Bato, Mr. Dows, and Mr. Sullivan. Mr. Bato's letter, in particular, indicates a remarkable breadth as well as depth of understanding.

His entire letter shows a background of culture and a knowledge of history unusual in an engineer.

Perhaps, though my personal observations have led me to doubt it, the majority of engineers are content to subsist on the highly localized interchange of "honor" with their associates, in lieu of greater remuneration. I, for one, am enough of a materialist to feel that I am, together with practically all of my associates, grossly underpaid, and I am ready at any time to trade my potential "professional" standing, which is of very questionable value, for a remuneration commensurate with what I firmly believe to be my contribution to society.

The bulk of the defense of the status quo seems to be based on the premise that no engineer could accept the "dictatorship" of a union business agent. The banner of this argument is carried, strangely enough, by those who praise the very union leaders whose policies have fostered and maintained the racketeers who dominate the majority of the older "horizontal" unions. They then go on to suggest that an engineer might join a "horizontal" union, but never (!) a "vertical" union. When reading over some of these references, I could not but wonder whether the terms might best be used to indicate whether the union in question was one to lay down and do nothing for its members, or stand up and really try to improve wages and working conditions. But be that as it may, one must, however, eventu-

[13] A sixth group of letters commenting on an article "Unionization of Engineers," by James H. Herron, MECHANICAL ENGINEERING, vol. 61, November, 1939, pp. 788–789 and 822.

ally return to the original premise of the discussion.

Whether one considers the younger and more militant Federation of Architects, Engineers, Chemists, and Technicians, or the older International Federation of Technical Engineers, Architects, and Draftsmen Unions, either one constitutes a horizontal or craft union, though hardly in the narrowest sense as applied to some of the older skilled trades. Vertical or industrial organization would mean the membership of the engineer in the one union covering the plant or bargaining unit.

Mr. Dows suggests, and then rejects the probable answer to this problem when he says, "There is the possibility that labor unions could be more valuable to a community if young engineers, with the ideals of the professional engineer, were to join the unions and take a leading part in the union activities." I firmly believe that if engineers are organized, it should be in a union of their own, rather than as part of the major labor unions, whether industrial or craft. I also believe, although the supine manner in which they have accepted their present role lends basis for doubt, that a union of the majority of employee engineers would not fall prey to domination by labor racketeers, and that such a union would have a very desirable effect in raising the standards of all labor organizations.

The second major argument seems to be that organization is beneath the dignity of the engineer and his professional ideals. Mr. Bato has done much to refute this misconception with his reference to the organizations of musicians and actors, not to mention medical and bar associations. Another example which has become almost classical in the last few years is that of the American Newspaper Guild.

It was but a few years ago we thought of the newspaperman as the most completely individualistic, unorganizable member of our modern economic machine. There was also the claim that "our news writers could never be subjected to the control that such a labor organization would then have over our free press." This has its parallel in "He has to have the confidence of the management so that decisions can be made freely. This trust placed in him is essential for the independent nature of his work, which elevates it from an occupation to a profession."

But now the American Newspaper Guild is an important organization, and its solutions to many of the problems of a "profession" form a valuable guide to the engineer in considering his problem. Obviously there are many types, classifications, and grades of work in the newspaper field. The contracts which are held by the Newspaper Guild are an outstanding model for study of what might be gained by the engineer through organization.

Many of the problems of classification, of minimum-wage scales and their meaning, of the relation of the "professional" to his employer, have already been solved in many cases. Security and job tenure are becoming increasingly important to the industrially employed engineer.

With the increasing practice of the large corporation to choose men while they are still in school, put them through a training or apprentice course, advance or discard them as occasion warrants, there is little security for the man who does not see eye to eye with his employer on questions such as the unionization of engineers, as well as on technical problems. This "training" of young graduates is accompanied by a strong discouragement of any attempt by the individual to gain broader experience by working for different companies in the same field, or experience in other fields. He must stay with one company or practically start over again in "training" if he is fortunate enough to secure a new position. His security is small indeed.

The American Newspaper Guild has, in many of its contracts, what seems to be an excellent answer to this problem. The "severance-pay" clause provides for approximately one week's severance pay for each six months of employment up to a maximum of possibly a year's salary. Such a protection would mean much to the man who feels bound by the narrow specialization of five, ten, or fifteen years spent in one company or branch of industry. A severance-pay clause is said to be included in the contract of an engineers' union with a company in San Francisco.

At the risk of seeming redundant, there are many other opinions in the discussion that cannot be passed over completely. It is interesting to note that Harry W. Snyder, who says that "Unionization is supposed to be for people who are unable to take care of their own needs. It is a fine engineer who can't do this," is listed in the A.S.M.E. membership roles as secretary, assistant to the vice-president, charge of manufacturing, of the H. P. Snyder Mfg. Co. While Mr. Snyder is probably a very capable young man who has merely taken advantage of the opportunity offered by a possible relationship, it is obvious that every engineer cannot have such a relationship.

Mr. Snelling says: "If the employer can and will settle all employer and employee questions with fairness and the employee has the desire to rise above the herd and is willing to do more than he is paid for to achieve that success, there is little reason for an engineering technician to join any union." Now there are outstanding and much publicized examples of employer fairness, examples seldom, if ever, accompanied by reports of labor troubles. But such fairness must be considered from both the relative and the absolute standpoint. He goes so far as to suggest organization for the employee suffering from an unfair employer, yet even that would do little to raise the standards of the entire engineering profession. Mr. Snelling also uses a much overworked catch phrase in his reference to the rights of the public as well as those of capital and labor. What is this "public" which seemingly exists independently of capital and labor? Is not the public made up exclusively of laborers, laborers who own some capital, and owners of capital, with the first of the three groups constituting a great majority of the entire public?

Mr. Abbott, an "old-timer," suggests that "the business of organizing and managing new unions is so profitable that prospectors are continually on the lookout for unorganized groups, that, at first by cajolery, and later by duress, may be brought under the wing of some powerful national union." While he should be well qualified to pass upon the profitableness of managing the established A.F.of L. craft unions, which are now held up as models of what labor organizations should be, it seems strange that this "profitable business" carried on under the leadership of the same parent organization for over forty years, succeeded in reaching only about four million out of more than forty million employees, and that only the combination of the worst economic depression our country has ever known, together with the recognition of the obsolescence of the craft form of organization, made possible the organization of the second ten per cent of our working population.

Mr. Dows brings out a very salient fact: "The very nature of the A.S.M.E. is such that it is managed by men who have very closely attained a professional status and are many years removed from the problems of earning a small living." Being in this category, although I am doing somewhat better than the average graduate engineer of my age in "earning a small living," my occasional contact

with the austere publication MECHANICAL ENGINEERING will continue to be through the kindness of a friend who still thinks it worth while to maintain his membership status in the society.

ALFRED JAMES.[14]

TO THE EDITOR:

I was very much interested by the excellent article of James H. Herron on the unionization of engineers and the ensuing discussion.

Mr. Herron has raised a question which is really a sociological problem. As in most problems of sociology we are handicapped by insufficient knowledge of important data. We know that the engineering profession comprises men who are hired and paid by the hour and at rates which are often inferior to those of good mechanics. We also know that we have men who offer their services to the public as consulting engineers and are in every respect independent. Between and beyond these limits we have men in all phases of engineering work and in all social strata.

We do not know, however, how many people are employed and working under all these different conditions, and it appears to me, therefore, that it is impossible to set up a general rule or pattern of behavior without previously undertaking an investigation which should be very thorough.

We should know first under what conditions the engineers work, how many engineers belong to the different groups, whether they are satisfied with the conditions under which they work, and furthermore, what their attitudes and aims are and what they propose to do to improve conditions they may judge unsatisfactory.

It seems to me that a survey should be made by the A.S.M.E., the Founder Societies, or the American Engineering Council to get a correct picture of the status of the engineer. This survey should not be limited to the members of the engineering societies but, if possible, should cover all people engaged in engineering. It could be done by a comprehensive census or, if this should prove too difficult and expensive, by a survey in the manner in which the modern public-opinion polls are conducted which seems to give results which are highly satisfactory.

The conclusions derived from the results of this survey will enable us to make better founded proposals for the appropriate type of organization. Up to now the engineering profession has differed from the other professions by the fact that it was always open to all men who have proved their engineering ability, regardless of their educational and social background. It is due in large measure to this practice that engineering has progressed so rapidly. Rather than to allow a split to develop or even to produce it by setting up standards which could be applied only to a small minority group, we should try to conserve this advantage and create the most comprehensive and liberal organization.

EUGENE HERVEY.[15]

TO THE EDITOR:

In evaluating the advisability of union organization for engineers, one is faced with a difficult problem which can be formulated as follows: Is unionization compatible with engineering as a profession, and will this emphasis on economic emoluments militate against the service which is performed by engineers?

As we survey the present world, we see that all the human interests are expressed in some organization which has for its purpose the development of this interest. We have social, athletic, artistic, scientific, religious, political, economic, and industrial, just to name a few. These organizations find their genesis in the realization that a well-knit group can, because of its organization and its numbers, better promote and benefit from such interest than can an isolated individual acting alone. Moreover, such groups, because of the facilities made possible by their structure, have been of great service to society.

Since the opportunity to practice engineering, to develop professionally, and to provide a proper environment for his family is largely dependent upon income, the engineer is interested in taking measures to assure an adequate one. The consultant bases his fee on a certain percentage of the total cost of the installation. This percentage has been fairly stabilized by a common understanding and usage. Such basis, however, does not exist for the employee-engineer whose salary is dependent in a large measure upon conditions in the field, an oversupply or scarcity of men available, and the degree of his own need.

The unions formed by actors, newspapermen, musicians, and teachers list in their memberships some of the outstanding men and women in their respective fields. These are honorable professions and their unionization has not hindered their professional progress. In present-day society, economic asceticism is not a prerequisite to technical perfection, and fair salaries do not subordinate the service performed, as can be judged by the remuneration received by outstanding people.

As an example of the service performed by an engineering union for members of the profession, the work of the Federation of Architects, Engineers, Chemists, and Technicians, C.I.O., can be considered. The Federation has in many cases been instrumental in obtaining salary increases and improvements in working conditions. In some of the cases, the assistance of the labor union in the same field contributed to the successes. The Federation operates a school, on a nonprofit basis, which offers numerous courses to all engineers and technicians. It has committees for the formulation of legislative programs and for the advice to its membership of the application of the various laws and codes pertaining to engineers and architects.

A service that such an organization can offer to the nation as a whole is well expressed in the following quotation from the address of Mr. Lewis at the Fourth National Convention of the Federation held in Washington, D. C., in December, 1938. He said: "Not only the labor movement but Americans as a whole need the advice and council and the help and the leadership and sustaining support of that great group of Americans who are embraced in the so-called white-collar professions, the architects and the chemists and technicians of high and low degree who contribute so much to the articulation, centralization, and the proper functioning of this highly complex modern machine, industrial and scientific America."

Events in our national life have focused attention on the need of solving economic and social problems with the same success that engineers have solved technical problems. We have splendid technical societies facilitating the development of the technical phases of engineering. We need economic organizations of engineers to facilitate the solution of the social problems resulting from technical developments.

B. L. SPIVAK.[16]

TO THE EDITOR:

As a student member of the A.S.M.E. and having formerly been both employee and employer, I have been interested in Mr. Herron's article and the subsequent

[14] New York, N. Y.

[15] Cleveland Heights, Ohio. Jun. A.S.M.E.

[16] New York, N. Y. Mem. A.S.M.E.

discussion on the question of engineers' unions.

Labor's goal is to get the shortest hours, highest wages, and best working conditions possible. Capital formerly wanted the maximum production at the least possible wage cost and cared nothing for working conditions. Now, capital realizes that improved working conditions make for more and better production.

The battles waged between the two groups concern where the line of demarcation lies. More recently, the main contention has been *who has a right* to set the location of that line rather than *where* it should be set.

It seems to the writer that as trained men interested in the welfare of both sides, for without either group we would have nothing to do, it is our duty to remain as nearly neutral as possible and act to bring about a much-needed improvement in the understanding between the factions. Only with harmony between the groups can an engineer hope for the efficiency of operation with which he is concerned.

If we align ourselves with the A.F. of L. or C.I.O., how can we maintain neutrality in labor disputes? After all, it is usually the engineers rather than the capitalists who come in contact with the wage earners.

Should engineers form their own union? This is more easily said than done. The work of most tradesmen can be easily defined in terms of production and they are on nearly an equal footing, in that, if an operator keeps a machine working at its rated capacity, he is as good as, but no better than, another worker. The earnings of the two should also be the same.

Engineers, on the other hand, have such varied duties and so much depends upon their ability to perform those duties that it would be difficult to set up fair trade standards for many of those in the profession. Engineers are somewhat like artists. Their output is not always constant and those with ability should be allowed some freedom of action to follow their own dictates rather than be regimented into a group of clock-watchers.

If the engineering profession sets a minimum-wage scale for the inexperienced man, such as the college graduate, so that the earnings of that group are increased materially, be assured of two results: First, it will be harder for graduates to obtain employment; and secondly, it will be harder to rise above the minimum rates, because the greater expense incurred by our training in industry will mean delayed salary increases. Financially, the systems may balance over a period of several years instead of bringing any marked improvement.

Reviewing the recent history of union actions, such as the jurisdictional strikes of the last few years, the high-handed and selfish practices at the Century of Progress Exposition and numerous lesser evidences of attempts at self-advancement regardless of the rights of others, it seems that engineers should try to find a better way of advancing the interests of their several professions than by labor unions as they are today.

BRAXTON H. TABB, JR.[17]

Nonexistent Difficulties in Welding

TO THE EDITOR:

Arc welding has too many doctors. An operation which is perfectly natural, very simple, and very easily accomplished has largely been changed in the minds of the public to an art which takes on the mystery of voodooism with an admixture of the art of the medicine man.

The public is beginning to think that the welding operator is a cross between a miracle man and a professional musician. This opinion is groundless. The only thing that a welding operator can do is to hold the end of an electrode at a certain distance above the deposited metal and advance it along the seam to be welded at a certain speed. There is nothing more that is involved in this operation. It is neither complicated nor difficult. As a matter of fact, with proper electrode, proper setting of the welding machine, and proper preparation of the work it is practically impossible to make a weld which will not stand up in service without having it so evident to the inspector that he would immediately reject it. It is possible to have defects in the steel that cannot be seen which will make a steel structure dangerous. It is impossible, however, to make a weld on that structure which is dangerous without its being obvious to anyone looking at the weld.

The reason we hear so much about the necessity of skill and care in welding is largely due to the fact that the operation itself is so simple that it is difficult to find much about it to discuss in papers, lectures, and statements. Therefore, many of these eccentricities which are volubly discussed in magazine articles, lectures, and statements consist of theoretical possibilities which exist only in the minds of the lecturers and seldom exist in reality.

[17] Blacksburg, Va.

It is time that we got away from trying to make this very simple operation mysterious. It is time that we recognize the fact that the metal deposited by the shielded-arc electrode is definitely better than the parent metal it is joining. It is time we recognize that there has never been a failure on an insured pressure vessel made by the shielded-arc process. It is time we recognize that in the usual design if only half a weld is made it will withstand all of the normal requirements of the structure. It is time we recognize that failures in welds which are made by the methods recommended by any reliable manufacturer never exist. It is time we recognize that there is no mystery in welding and that making a welded joint is far more simple than making a riveted joint and more simple than making the steel which is joined together by this process. It is time we recognize that to spend time, money, and attention in removing the least possible flaw from the deposited metal is silly in the light of the obvious flaws which must occur in the parent metal. A factor of safety is used to guard against these flaws. That is more than is needed in any commercial weld.

When we do recognize these facts we will have done two things: First, we will have given the green light to one of the most economical processes now known for the production of many structures; secondly, we will have removed one of the fears which the uninitiated have developed regarding a perfectly normal manufacturing operation.

J. F. LINCOLN.[18]

Quick-Acting Release Latches

TO THE EDITOR:

Early in the article[19] the author groups all latches into four classes, and shows only those used "on center" and "over center." Classes might reasonably be added to include (1) slip-off latch with release trigger, and (2) slip-off toggle latch with release trigger.

A slip-off latch with release trigger is illustrated in typical form in Fig. 1 of this discussion. Latches of this construction can be used on very large circuit breakers which impose heavy loads on the mechanism. They also have the advantage of being able to release the breaker in a short elapsed time after the trip coil has

[18] President, The Lincoln Electric Co., Cleveland, Ohio. Mem. A.S.M.E.

[19] "Quick-Acting Release Latches," by Carl Thumim, MECHANICAL ENGINEERING, November, 1939, pp. 807–812.

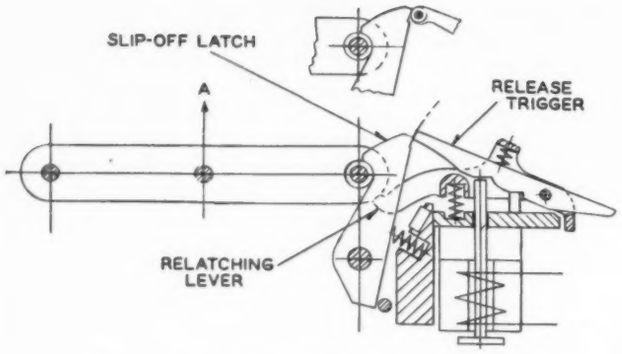


FIG. 1 SLIP-OFF LATCH WITH RELEASE TRIGGER

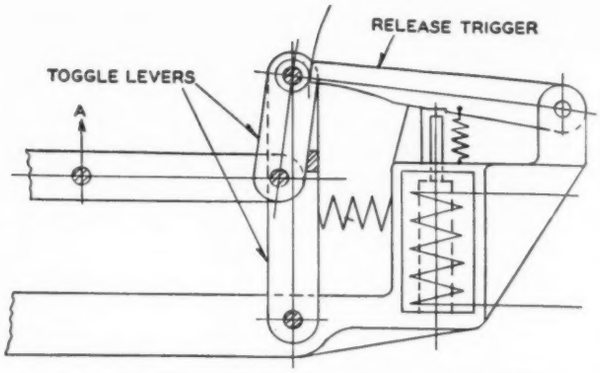


FIG. 2 SLIP-OFF TOGGLE LATCH WITH RELEASE TRIGGER

been energized. The latch is designed to be positioned on the roller of the breaker-operating lever in such a way that, when the trigger is moved from its engaging point, the latch member will slip off the roller.

In this design of latch and trigger there is rubbing friction between the trigger and the latch. For breakers of ordinary size, the amount of friction at this point does not require the use of large trip coils. On heavy breakers, where latch loads are high, the rubbing friction at this point may be reduced by the use of a roller as indicated in a small sketch in Fig. 1. The amount of tripping energy required to disengage the trigger and thus release the latch in a practical mechanism design can be readily increased or decreased. Since both the latch and trigger are biased to the engaging position, provision is made for relatching the mechanism. A relatching lever biases the trigger and latch to the disengaged position until the mechanism lever has reached the latching position. It is operated by the mechanism lever and makes the relatching operation positive.

A slip-off toggle type of latch is shown in Fig. 2 of this discussion. Latches constructed in this manner have very low tripping loads, but are suitable where only moderate unlatching time is required. Another type of slip-off latch with a toggle trigger is shown in Fig. 3 of this discussion. The tripping energy for latches constructed in this manner is very low, but short release time is not readily obtained. Fig. 4 also illustrates a slip-off type of latch on which the tripping effort is reduced to a minimum by means of rollers. The amount that friction can be reduced by the use of rollers will depend largely on the design of the roller and its bearings. Friction can be reduced to a negligible amount by the use of carefully designed bearings and roller-type latches.

The author, referring to Fig. 8 of the paper, used a load of 100 lb at *A* to calculate the effect of friction to determine the load at *J*. Using 25 per cent for friction, he obtained values of 5.5, 11, and 14 lb for classes 1, 2, and 3, respectively, at tripping point *J*. These values are likely to be misleading and are applicable only to small breakers. In the design of large oil circuit breakers, it is not uncommon to encounter loads in the order of 3000 lb at *A*. In rare cases, the loading might even double this amount. Assuming a load of 3000 lb instead of 100 lb, which the author has used, then the loading at *J* for classes 1, 2, and 3 would be 165, 330, and 420 lb, respectively. A trip coil capable of releasing the breaker when operating under these loads would be large, and would not only draw a prohibitive current but would be slow-acting. When it is necessary to deal with breaker loads in the order of 3000 lb, and still maintain high-speed operation with small trip coils, the latch arrangement shown in Fig. 1 of this discussion, or some of its modifications, is ideal.

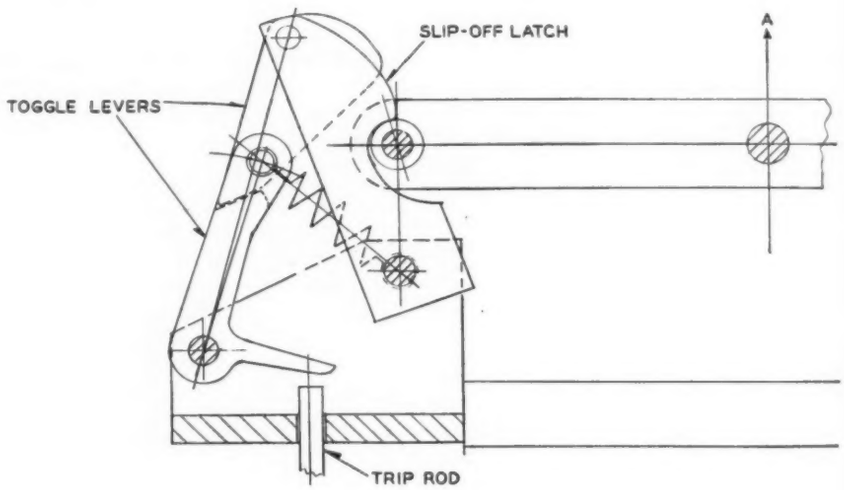


FIG. 3 SLIP-OFF LATCH WITH TOGGLE TRIGGER

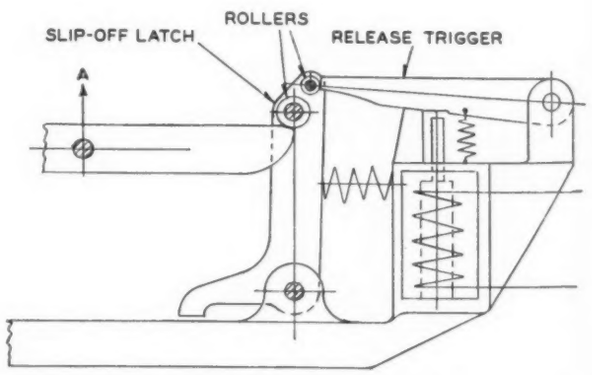


FIG. 4 SLIP-OFF LATCH WITH RELEASE TRIGGER AND ROLLER

The tripping effort required at point *J* to disengage the latch can be varied over a considerable range by the selection of the slip-off angle used, and the proportioning of the latch and trigger. In practical designs, and for comparable loads, it would be very much below the values given in the paper for classes 1, 2, and 3.

In the closing paragraph, the author evaluates the performance characteristics of latches, classes 1, 2, and 3, and classes 1 plus 4. In his evaluation, he gives the class 1 latch the highest rating of 25 points. We believe the author should limit the use of the evaluation to breakers of small size.

H. J. LINGAL.[20]

TO THE EDITOR:

In the original paper, latches were resolved into the elementary types which could be combined or superimposed, as illustrated in Fig. 5 and described in the text relevant thereto. The additional classes proposed by Mr. Lingal are simply combinations of the elementary types. The latch shown in Fig. 1 of his comment, can be considered a concatenation of two class 3 latches; his Fig. 2, a superposition of the class 1 on the class 2 type, and his Fig. 3, a superposition of the class 2 on the class 3 latch. It goes without saying that an infinite number of combinations may be made, for there is nothing to stop the use of any number of latches in a chain except practical considerations.

The matter of reducing friction by means of rollers and antifriction bearings is discussed in the paper.

The author agrees that forces of the order of 3000 lb are encountered. Instead of building a chain of latches and thereby multiplying all their errors, he prefers to supply the necessary tripping force. He also agrees that a trip coil would be slow and would require excessive current. However, if the class 4 flux-shifting type of magnetic latch is used, currents are normal, of the order of 10 amp, speed is much greater, and tripping forces of the magnitude of 500 lb are easily obtained. Such an arrangement was shown in Fig. 11 of the paper. (Fig. 6 of this letter.)

An attempt was made to obtain a comparison of the different classes by analyzing them under comparable conditions, such as zero friction and equal trip distances. The numerical values are not absolute but comparative. When the slip-off angle in the class 3 latch is made flatter, as suggested by Mr. Lingal, to reduce tripping force, its disadvantages are simply emphasized. A slight variation due to manufacture or wear would make a large change in the tripping force. To obtain the optimum angle, hand-honing at assembly would be necessary. Such latches have been known to lose their reliability and shockproofness after short service.

Mr. Lingal's final conclusion that these latches, as designed, would be limited to breakers of small size is unfounded. As a matter of fact, the class 1 and the class 4 latches, singly and in combination are employed on the most powerful and the highest-speed circuit-breaker-operating mechanisms built by the General Electric Company, among them being the 3-cycle, 287,000-v breakers used on the transmission line between Boulder Dam and Los Angeles.

CARL THUMIM.[21]

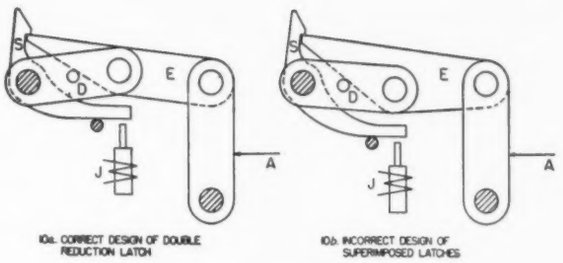


FIG. 5 DOUBLE-REDUCTION LATCHES

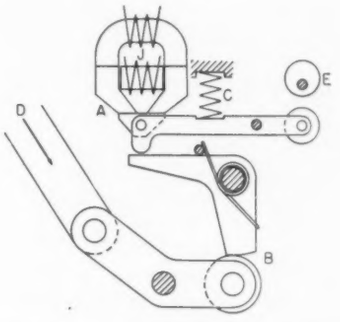


FIG. 6 CLASS 4 LATCH USED TO SUPPLY TRIPPING FORCE

Railway-Car Engineering

TO THE EDITOR:

Mr. Ellis' excellent paper[22] covers a large subject but because of space limitation he could touch only lightly on its various phases. Modern passenger-train cars must provide not only adequate passenger safety, comfort, and appeal, but also be suitable for economic operation.

Under the latter heading, reduced weight without sacrifice of safety and in the face of higher transportation speeds presents the major problem of the car designer. Marked reduction in weight has been made and this reduction has been largely accomplished by balancing of the design.

A balanced design is one in which the various members of the structure are so proportioned that under the different load or shock applications, the unit stress in the members is kept as nearly the same as possible. This in itself has accounted for a substantial proportion of the weight saving. We have the new materials with their higher unit-strength value. These materials, however, may not be used to the same proportion of their yield strength as has been and is permissible with low-carbon open-hearth steel, due to the greater deflection these new materials will have under the higher unit stresses to which they are subjected. However, it is possible to use considerably higher stresses and therefore effect substantial savings.

Welding has played an important part in this weight-saving program due to the ability to use the full area of the members, which is not the case with riveted joints. Welding also materially assists in the use of higher-tensile-value materials as in a welded structure the deflection of the individual members is, under a given unit stress, substantially less than in a riveted structure.

The car designer should be permitted to use materials and method of fabrication best suited for the member in question. Commercialism—that is, cost—should be carefully studied and should have a substantial bearing on the type of material and construction used. For instance, in a car structure there may be places where low-carbon open-hearth steel is best suited; other places, low-alloy high-tensile steel. Stainless steel, aluminum alloys, as well as synthetic materials all have proper places in car construction. This applies also to the use of welding or riveting or both for assembling the members.

Stainless steel with its high material cost and the necessity of cold rolling to obtain high strength to make its use economical, to the writer's mind has no place as a strength member in a car structure. The cold rolling to produce the higher strength value produces a material that stretches more under given stresses than other steels, and therefore deflects more under eccentric stresses and thus more quickly builds up secondary stresses that are too often the cause of structural failures.

Reference is made to the so-called squeeze test wherein under the pressure stated, the car deflection was 0.9 in. An 85-ft passenger-car structure built of low-alloy high-tensile steel placed in the

[20] Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

[21] Designing Engineer, General Electric Company, Philadelphia, Pa.

[22] "Railway-Car Engineering," by D. S. Ellis, MECHANICAL ENGINEERING, January, 1940, pp. 18–22.

same machine had a deflection of half of the amount given, that is, 0.45 in. under slightly less load, namely, a load of 905,600 lb.

In designing lightweight freight cars, especially the 50-ton nominal capacity open-top car, the use of low-alloy high-tensile steel, to reduce weight, is under a serious handicap. This also applies to the 50-ton nominal capacity boxcar. This handicap is the braking percentage requirement. To follow the A.A.R. Air Brake Committee's recommendation of not less than 18 per cent of the rail-load limit and not less than 60 or more than 75 per cent of the lightweight of the car, means that for any car wherein light weight is less than 40,560 lb the empty and load-brake equipment is needed.

Numerous lightweight boxcars have been built at substantially lower weights than that just given. Numerous designs of low-alloy high-tensile steel hopper cars of 50-ton nominal capacity have been built with weights as low as 33,500 lb. On this latter car the empty and load brake was applied and the weight includes the approximately 500 lb penalty which this extra equipment entailed as well as somewhere in the neighborhood of $200 extra cost.

As long as this braking requirement is in effect, any material reduction in weight of freight cars of 50- or 70-ton nominal capacity is seriously handicapped.

VICTOR WILLOUGHBY.[23]

TO THE EDITOR

Mr. Ellis' paper on "Railway-Car Engineering" covers, in comprehensive and conveniently condensed form, the present trend of passenger- and freight-car design. The conclusions are well drawn and are perhaps not overconservative regarding trends in future construction.

The value of the paper as a reference would seem to justify the addition to Table 1 of the physical properties of alloy cast steel commonly known as high-tensile cast steel for car construction. These properties are shown in Table 1 accompanying this comment.

A considerable number of freight cars have been built using this type of high-tensile cast steel, especially in trucks, couplers, draft yokes, and other types of castings. The Association of American Railroads alternate standard coupler for passenger cars, known as the tight-lock coupler, is also of high-tensile cast steel.

The tight-lock coupler is of especial interest and value in the construction of modern passenger cars and contributes largely to the advantages of traveling by rail. The specific advantages are

[23] Vice-President, American Car and Foundry Company, New York, N. Y. Mem. A.S.M.E.

TABLE 1 PHYSICAL PROPERTIES OF ALLOY CAST STEEL

Trade name	Kind of finished material	Heat-treatment	Physical properties: Tensile strength, lb per sq in.	Yield point, lb per sq in.	Elongation in 2 in., per cent	Reduction in area, per cent
Cast steel	Trucks, couplers, draft yokes, miscellaneous castings	Heat-treated	90,000 min	60,000 min	22 min	45 min

mentioned in Mr. Ellis' paper under the headings: Safety of operation at required speeds; dissipation of excess noises; freedom from jolts and bad starts; comfort in stopping from high or low speeds.

Before the A.A.R. tight-lock coupler was adopted as an alternate standard, it was subjected to a series of severe tests to insure its ability to meet the strength requirements of the car structure as a whole. The ability of the tight-lock coupler to intercouple with the A.A.R. standard "E" coupler, together with its other advantages mentioned, is bringing it into extensive and widespread use on modern passenger equipment.

H. W. STERTZBACH.[24]

Railway Mechanical Engineering

TO THE EDITOR:

In connection with the report[25] of Committee RR6 of the A.S.M.E. Railroad Division on "Progress in Railway Mechanical Engineering," The D. & H. Railroad Corporation's tests of an all-welded locomotive boiler over a period of two years reveal that the boiler has given satisfactory performance. The welded boiler, from a railroad standpoint, has two outstanding qualifications: (1) freedom from embrittlement, and (2) saving in weight. This boiler did not give as great a saving in weight as can ordinarily be expected in modern locomotives, because it has short tubes and an exceptionally large firebox. This design, adopted because the fuel used is a mixture of bituminous and anthracite coal, resulted in an actual weight saving of about 5 per cent. With other designs we can usually expect a weight saving of approximately 10 per cent for welded construction.

JAMES PARTINGTON.[26]

TO THE EDITOR:

Reference is made to steam-locomotive design and construction developments during the year, which indicate that the trend in this country is toward boiler pressures of 300 to 350 psi and single-expansion cylinders.

Increased locomotive efficiency through the use of high steam pressures necessitates a higher degree of expansion than is possible with simple cylinders; André Chapelon[27] has pointed out that the French resort to compounding, with high superheat also an essential. Are the French better engineers than we in America? I do not so admit, but for some reason American engineers have relegated compounding in steam-locomotive practice to the past.

I realize that it was the lower maintenance cost and greater availability of the simple superheater locomotive that laid the saturated compounds of 30 years ago on the shelf in this country. Nevertheless, I believe that if the full economies of the reciprocating steam locomotives are to be realized, we should again utilize the principle of the balanced compound, taking full advantage of the better materials and improvements in appliances, shop tools, and equipment for adapting the design to modern conditions.

While not all of the compound locomotives in service thirty years ago were of the balanced type or had outstanding characteristics, the Atlantic-type four-cylinder balanced compounds of that day were, per unit of weight, the equal in speed, power, and economy of any ever built in this country. They were saturated locomotives that could make a smooth start and handle their tonnage in the equipment of the day at speeds up to 85 mph. With superheated steam, roller bearings, mechanical lubricators, and the installation of modern locomotive accessories, these locomotives, handling modern lightweight train equipment, would have no difficulty in making present schedules, and undoubtedly would show a performance that might surprise advocates of designs of streamlined steam power in use today on American railroads.

JOHN R. JACKSON.[28]

[24] Chief Mechanical Engineer, The Buckeye Steel Castings Company, Columbus, Ohio. Mem. A.S.M.E.

[25] Published in MECHANICAL ENGINEERING, December, 1939, pp. 863–875.

[26] Manager, Engrg. Dept., American Locomotive Co., New York, N. Y. Mem. A.S.M.E.

[27] "La Locomotive à Vapeur," by André Chapelon, J. B. Bailliere et fils, Paris, 1938. Reviewed by Lawford Fry in *Railway Mechanical Engineering*, vol. 112, December, 1938, p. 473, and vol. 113, January and September, 1939, pp. 1 and 345.

[28] Engineer of Tests, Missouri Pacific Lines, St. Louis, Mo. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place in the code.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-9*a*. Add the words "or Specification S-33, grades C-11 or C-4" to the first sentence.

PAR. P-186*d*. Revise last section to read:

When nonpressure parts are attached by fusion welding and the drums and parts are subsequently heat-treated or stress-relieved in accordance with Par. P-108, OR WHEN THE WELD METAL HAS A THROAT THICKNESS OF NOT MORE THAN 1/4 IN., no deductions need be made on account of the welds. THIS RULE IS ONLY APPLICABLE WHERE THE MINIMUM OF THE RANGE OF THE TENSILE STRENGTH OF THE PLATE TO BE SEAL WELDED DOES NOT EXCEED 70,000 LB PER SQ IN., AND THE CARBON CONTENT OF THE PLATE DOES NOT EXCEED 0.35 PER CENT.

PARS. P-196*b* and U-37*b*. Add the words "using C = 0.40."

PAR. P-300. Modify proposed addition to third section, appearing in April, 1940, issue of MECHANICAL ENGINEERING, to read as follows:

When welded piping that is covered by this Code is fabricated by anyone other than the manufacturer of the boiler, the welding shall be done IN ACCORDANCE WITH PAR. P-112 AND by a fabricator in possession of the code symbol stamp for piping shown in Fig. P-44 1/2.

TABLE A-8. This table will be revised to make it correspond to American Standard for Cast-Iron Pipe Flanges and Flanged Fittings, Class 250 (ASA B16b–1939).

Fig. P-5 1/2(*b*). This illustration will be revised by the deletion of the words "suitable for gas welding only."

TABLE P-6. The stresses in this table will be revised to make them consistent with the proposed revision of Table P-9.

TABLE P-9. See pages 486–487 of this issue.

TABLE U-3. This table will be revised to be identical with the proposed revision of Table P-9 with the addition of the following footnote:

"Any material in this table may be used at temperatures below —20 F provided it complies with Par. U-142. To meet these requirements special melting practice, analysis, and treatments are generally necessary. The allowable stress shall be that given for room temperatures in the table.

Specification S-19. This specification will be revised to make it identical with A.S.T.M. Specification A72–39.

Specification S-52 (A.S.T.M. A213). Reference to this specification will appear in Pars. P-11, P-21*a*, P-103*a*, Table A-14.

Specification S-56 (A.S.T.M. A212). This specification will replace present Specification S-26 and S-27; therefore wherever reference is made to the latter, it will be revised to read "S-56."

A.S.T.M. Specifications A216 and A217. The Committee has tentatively approved the adoption of these specifications.

PAR. U-1*a*. Revise to read:

a The rules in this section apply to unfired pressure vessels of which the diameter is over 6 in., and for internal or external pressures over 15 lb per sq in. However, vessels under 6 in. in diameter may be constructed under these rules if provided with proper safety devices.

These limitations apply to each single vessel and not to an assembly of vessels.

PAR. U-4. Revise to read:

U-4. The pressure at which a safety device is set to operate SHALL NOT BE IN EXCESS OF THE MAXIMUM ALLOWABLE PRESSURE STAMPED ON THE VESSEL AND must include the effect of static head, if any, at the place at which the device is connected.

PAR. U-13*g*(3). Revise to read:

(3) WORKING STRESSES FOR THE SEVERAL CLASSES OF CAST IRON AS GIVEN BELOW SHALL BE USED IN APPLYING THOSE FORMULAS OF THE CODE THAT ARE APPLICABLE TO THE DESIGN OF CAST-IRON PARTS:

CLASS	MAXIMUM TENSION	MAXIMUM BENDING	MAXIMUM COMPRESSION
20	2000	3000	4000
30	3000	4500	6000
40	4000	6000	8000

[A working stress not to exceed 2500 lb per sq in. shall be used in designing cast-iron pressure parts of such shape that the rules of this Code for calculating pressure are applicable.]

PAR. U-36*c*. Replace the proposed addition, as published in the April, 1940, issue of MECHANICAL ENGINEERING, by the following:

In a multipiece welded head if the center of such a flanged-in type manhole (over 6 in. in any dimension) is not closer to a welded joint than a distance equal to the maximum dimension of the manhole, the added thickness required shall be based on the required thickness for a seamless (one-piece) blank head. If the distance of the manhole from a welded joint is less than this, or if it crosses the weld, the added thickness shall be based on the required thickness for a welded blank head.

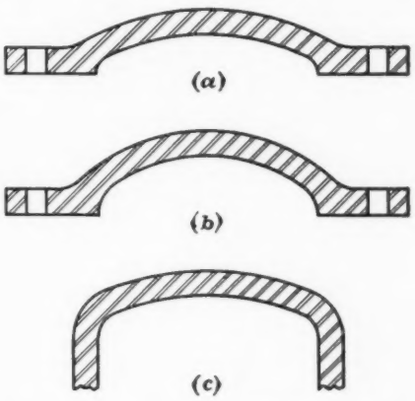


FIG. U-1 1/2 TYPICAL FORMS OF CAST IRON HEADS

PAR. U-37. Add the following sections:

c Circular cast-iron blank spherically dished heads with bolting flanges (dished cover plates) for either internal or external pressure (Fig. U-1 1/2*a*) shall be calculated by the formula:

$$t = \frac{10 \times P \times L}{2 \times TS}$$

where t = thickness of dished portion, in.,
P = maximum allowable working pressure, lb per sq in.,
L = radius to which head is dished measured on the concave side of the head, in., but not to exceed the inside diameter of the shell to which the head is attached,
TS = minimum tensile strength of the class of material used.

The plane of the bolting flange shall be at right angle to the axis of the head. The flange dimensions shall not be less than the several American Standards for cast-iron fittings of the same diameters.

If of a semiellipsoidal form (Fig. U-1 1/2*b*) in which the inside depth of the head (one half of the minor axis of the ellipse) does not exceed one quarter of the inside diameter of the shell to which the head is to be attached, the thickness of the head shall be at least that required for a cast-iron cylinder with that diameter.

(*Continued on page 487*)

Table P-9 Revised

TABLE P-9 MAXIMUM ALLOWABLE WORKING STRESSES FOR FERROUS MATERIALS IN LB PER SQ IN.

Specification number	Grade	Spec. minimum tensile	Notes and limitations	For metal temperatures not exceeding deg F: —20 to 650	700	750	800	850	900	950	1000	1050	1100	1150	1200
PLATE STEELS															
Carbon Steel															
S-1		55000	(1)	11000	10400	9500	8000	6300	4400	2600	..	..	..	..	..
S-2	A	45000	(1)	9000	8800	8400	6900	5700	4400	2600	..	..	..	..	..
S-2	B	50000	(1)	10000	9600	9000	7500	6000	4400	2600	..	..	..	..	..
S-26	A	65000		12000	12300	11100	9400	7600	5600	3800	2000	..	..	..	..
S-26	B	70000		14000	13300	11900	10000	7800	5600	3800	2000	..	..	..	..
S-27	A	65000		13000	12300	11100	9400	7600	5600	3800	2000	..	..	..	..
S-27	B	70000		14000	13300	11900	10000	7800	5600	3800	2000	..	..	..	..
S-42	A	55000		11000	10400	9500	8500	7200	5600	3800	2000	..	..	..	..
S-42	B	60000		12000	11400	10400	9100	7400	5600	3800	2000	..	..	..	..
Low-Alloy Steels															
S-28	A	75000		15000	14100	12400	10100	7800	5600	3800	2000	..	..	..	..
S-28	B	85000		15000	14100	12400	10100	7800	5600	3800	2000	..	..	..	..
S-43	A	65000		13000	12300	11100	9400	7600	5600	3800	2000	..	..	..	..
S-43	B	70000		14000	13300	11900	10000	7800	5600	3800	2000	..	..	..	..
S-43	C	75000		15000	14100	12400	10100	7800	5600	3800	2000	..	..	..	..
S-44	A	65000		13000	13000	13000	12500	11500	10000	8000	5000	..	..	..	..
S-44	B	70000		14000	14000	14000	13500	12000	10200	8000	5000	..	..	..	..
S-44	C	75000		15000	15000	15000	14400	12700	10400	8000	5000	..	..	..	..
Medium and High Alloy Steels															
A.S.T.M. A176-39	1	70000		14000	14000	14000	12800	9500	6750	4000	2400	..	..	..	..
A.S.T.M. A176-39	2	70000		14000	14000	14000	12800	9500	6750	4000	2400	..	..	..	..
A.S.T.M. A167-39	304, 308	75000	(2)	15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
A.S.T.M. A167-39	316, 317	75000	(2)	15000	15000	14000	14000	13900	13400	12600	11200	9000	7000	5000	3600
A.S.T.M. A167-39	321	75000		15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
A.S.T.M. A167-39	347	75000		15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
PIPE AND TUBES															
Seamless Carbon Steel															
S-17	A	...	(3)	9400	9100	8600	7900	6800	5600	3800	2000	..	..	..	..
S-17	A	...		9400	9100	8600	7150	5850	4400	2600	..	..	..	..	..
S-17	B	...		8000	7650	6900	..	..	..	..	..	..	..	..	..
S-18	Low carbon	48000	(3)	9400	9100	8600	7900	6800	5600	3800	2000	..	..	..	..
S-18	Low carbon	48000		9400	9100	8600	7150	5850	4400	2600	..	..	..	..	..
S-18	Med. carbon	62000	(3)	12000	11400	10400	9100	7400	5600	3800	2000	..	..	..	..
S-18	Med. carbon	62000		12000	11400	10400	8300	6350	4400	2600	..	..	..	..	..
S-40	A	...		9400	9100	8600	7900	6800	5600	3800	2000	..	..	..	..
S-49		60000		12000	11400	10400	9100	7400	5600	3800	2000	..	..	..	..
Seamless Alloy Steel															
S-45	P1	55000		11000	11000	11000	10750	10500	10000	8000	5000	..	..	..	..
S-48	T1	55000		11000	11000	11000	10750	10500	10000	8000	4400	..	..	..	..
S-48	T1a	60000		12000	12000	12000	11500	11000	10000	8000	4400	..	..	..	..
S-34	P3a	60000		12000	12000	12000	12000	11850	10750	8250	5850	3850	2200	..	..
S-34	P3b	60000		12000	12000	12000	12000	11850	10750	8250	5850	3850	2200	..	..
S-34	P5a	60000	(7)	12000	12000	12000	12000	11850	10750	8250	5850	3850	2200	..	..
S-34	P5c	60000		11000	11000	11000	11000	10860	10000	8250	5850	3850	2200	..	..
S-34	P8a	75000	(2)	15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
S-34	P8b	75000		15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
S-34	P11	60000		12000	12000	12000	12000	11850	10750	8250	5850	3850	2200	..	..
S-52	T3	60000		12000	12000	12000	12000	11850	10750	8250	5850	3850	2200	..	..
S-52	T5	60000		12000	12000	12000	12000	11850	10750	8250	5850	3850	3200	..	..
S-52	T11	60000		12000	12000	12000	12000	11850	10750	8250	5850	3850	2200	..	..
S-52	T12	60000		12000	12000	12000	12000	11850	10750	8250	5850	3850	2200	..	..
S-52	T14	60000		12000	12000	12000	12000	11850	10750	8250	5850	3850	2200	..	..
S-52	T16	60000		11000	11000	11000	11000	10850	10000	8250	5850	3850	2200	..	..
S-52	T8	75000	(2)	15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
S-52	T18	75000		15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
S-52	T19	75000		15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
S-52	T20	75000	(2)	15000	15000	14000	14000	13900	13400	12600	11200	9000	7000	5000	3600
FORGINGS															
Carbon Steels															
S-4	1	60000	(3)	12000	11400	10400	9100	7400	5600	3800	2000	..	..	..	..
S-4	2	70000		14000	13300	11900	10000	7800	5600	3800	2000	..	..	..	..
S-4	3	75000		15000	14100	12400	10100	7800	5600	3800	2000	..	..	..	..
S-8	1	60000		12000	11400	10400	8300	6350	4400	2600	..	..	..	..	..
S-8	2	70000		14000	13300	11900	8950	6450	4400	2600	..	..	..	..	..
S-8	1	60000	(3)	12000	11400	10400	9100	7400	5600	3800	2000	..	..	..	..
S-8	2	70000	(3)	14000	13300	11900	10000	7800	5600	3800	2000	..	..	..	..
S-10	A-Untreated	47000		9400	9100	8600	7150	5850	4400	2600	..	..	..	..	..
S-10	B-Untreated	60000		12000	11400	10400	8300	6350	4400	2600	..	..	..	..	..
S-10	C-Annealed	60000		12000	11400	10400	8300	6350	4400	2600	..	..	..	..	..
S-50	1	60000		12000	11400	10400	8300	6350	4400	2600	..	..	..	..	..
S-50	2	70000		14000	13300	11900	8950	6450	4400	2600	..	..	..	..	..
S-50	1	60000	(3)	12000	11400	10400	9100	7400	5600	3800	2000	..	..	..	..
S-50	2	70000	(3)	14000	13300	11900	10000	7800	5600	3800	2000	..	..	..	..
Alloy Steels															
S-35	F1	70000		14000	14000	14000	13500	12000	10200	8000	5000	..	..	..	..
S-35	F3	70000		14000	14000	14000	14000	13400	11000	8250	5850	3850	2200	..	..
S-35	F4	90000		15000	15000	15000	14000	12500	10000	6000	4000	..	..	..	..
S-35	F5	90000	(7)	15000	15000	14000	14000	13400	11000	8250	5850	3850	2200	..	..
S-35	F6	85000		15000	14000	13000	11500	9500	6750	4000	2400	..	..	..	..
S-35	F7	100000		15000	15000	15000	14400	12700	10400	8000	5000	..	..	..	..
S-35	F8	75000	(2)	15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
S-35	F11	100000		15000	15000	15000	14400	12700	10400	8000	5000	..	..	..	..
Electric-Resistance Welded															
S-32	A	...	(3), (4)	9400	9100	8600	7900	6800	5600	3800	2000	..	..	..	..
S-32	A	...	(4)	9400	9100	8600	7150	5850	4400	2600	..	..	..	..	..
S-32	B	...	(4)	8000	7650	6900	..	..	..	..	..	..	..	..	..
S-32	C	60000	(3), (4)	12000	11400	10400	9100	7400	5600	3800	2000	..	..	..	..
S-32	C	60000	(4)	12000	11400	10400	8300	6350	4400	2600	..	..	..	..	..
Lap-Welded															
S-17	Steel	...	(4)	9000	8800	8400	6900	5700	4400	2600	..	..	..	..	..
S-18	Steel	45000	(4)	9000	8800	8400	6900	5700	4400	2600	..	..	..	..	..
S-17	Wrought iron	...	(4)	8000	7650	6900	..	..	..	..	..	..	..	..	..
S-19	Wrought iron	40000	(4)	8000	7650	6900	..	..	..	..	..	..	..	..	..
Butt-Welded															
S-18	Steel	45000	(4)	9000	8800	8400	..	..	..	..	..	..	..	..	..
S-19	Wrought iron	40000	(4)	8000	7650	6900	..	..	..	..	..	..	..	..	..
Fusion-Welded															
S-1		55000	(4), (5)	11000	10400	9500	8000	6300	4400	2600	..	..	..	..	..
S-2	B	50000	(4), (5)	10000	9600	9000	7500	6000	4400	2600	..	..	..	..	..
S-2	A	45000	(4), (5)	9000	8800	8400	6900	5700	4400	2600	..	..	..	..	..

(*Table P-9 continued on following page*)

TABLE P-9 (*Continued*)

Specification number	Grade	Spec. minimum tensile	Notes and limitations	For metal temperatures not exceeding deg F: —20 to 650	700	750	800	850	900	950	1000	1050	1100	1150	1200
CASTINGS															
Carbon Steel															
S-11	B & B2	70000	(6), (8)	14000	13300	11900	8950	6450	4400	2600	..	..	..	..	..
S-12		70000	(8)	14000	13300	11900	10000	7800	5600	3800	..	..	..	..	..
A.S.T.M. A216-39T.	WCA	60000	(3), (8)	12000	11400	10400	9100	7400	5600	3800	2000	..	..	..	..
A.S.T.M. A216-39T.	WCB	70000	(3), (8)	14000	13300	11900	10000	7800	5600	3800	2000	..	..	..	..
Alloy Steel															
S-33	C1	70000	(8)	14000	14000	14000	13500	12000	10200	8000	5000	..	..	..	..
S-33	C3	100000	(8)	15000	15000	15000	14000	13400	11000	8250	5850	3850	2200	..	..
S-33	C4	100000	(8)	15000	15000	15000	14000	12500	10000	6000	4000	..	..	..	..
S-33	C5	100000	(7), (8)	15000	15000	15000	14000	13400	11000	8250	5850	3850	2200	..	..
S-33	C6	85000	(8)	15000	14000	13000	11500	9500	6750	4000	2400	..	..	..	..
S-33	C9	70000	(2), (8)	14000	14000	13000	12300	11700	11000	10500	10000	8500	5600	4200	3200
S-33	C11	100000	(7), (8)	15000	15000	15000	14400	12700	10400	8000	5000	..	..	..	..
A.S.T.M. A217-39T.	WC1	70000	(8), (9)	14000	14000	14000	12500	12000	10200	8000	5000	..	..	..	..
A.S.T.M. A217-39T.	WC1A	70000	(8)	14000	13650	12950	12000	9900	7800	5900	3500	..	..	..	..
A.S.T.M. A217-39T.	WC2	65000	(8), (9)	13000	13000	13000	12500	11500	10000	8000	5000	..	..	..	..
A.S.T.M. A217-39T.	WC4	80000	(8), (9)	15000	15000	15000	14000	12500	10000	6000	4000	..	..	..	..
BOLTING															
Carbon Steel															
S-7		55000	(10)	...	...	...	...	...	...	...	...	..	..	..	..
Alloy Steel															
S-9	A		(11), (12)	13000	11950	10900	...	...	...	...	...	..	..	..	..
S-9	B		(11), (12)	15000	13750	12500	...	...	...	...	...	..	..	..	..
S-9	C		(11), (12)	16000	14700	13400	...	...	...	...	...	..	..	..	..
A.S.T.M. A193-39T.	B4		(11), (12)	16000	16000	16000	16000	13000	10000	...	...	..	..	..	..
A.S.T.M. A193-39T.	B5		(11), (12)	16000	16000	16000	16000	13800	11000	8250	5850	3850	2200	..	..
A.S.T.M. A193-39T.	B6		(11), (12)	16000	14700	13400	11500	9500	6750	...	...	..	..	..	..
A.S.T.M. A193-39T.	B7		(11), (12)	16000	16000	16000	16000	13000	10000	...	...	..	..	..	..
A.S.T.M. A193-39T.	B7a		(11), (12)	16000	16000	16000	16000	13800	11000	8250	5850	3850	2200	..	..
A.S.T.M. A193-39T.	B8		(2), (11)	15000	15000	14000	13000	12000	11000	10500	10000	8500	5600	4200	3200
A.S.T.M. A193-39T.	B11		(11), (12)	16000	16000	16000	16000	13000	10000	...	...	..	..	..	..
A.S.T.M. A193-39T.	B13		(11), (12)	16000	16000	16000	16000	13800	11000	8250	5850	3850	2200	..	..
A.S.T.M. A193-39T	B14		(11), (12)	16000	16000	16000	16000	15000	13300	11400	8800	5000	2200	..	..
A.S.T.M. A193-39T.	B15		(11), (12)	16000	16000	16000	16000	13800	11000	8250	5850	3850	2200	..	..

NOTES:

(1) Flange quality not permitted above 850 F.

(2) No allowance has been made for corrosive action in the allowable stresses given. Carbide precipitation in service is also to be expected at temperatures above 750 F.

(3) These stresses permitted only if .10 per cent minimum silicon is expressly specified.

(4) These are base stresses for the material; these stresses are modified in Table P-6 to take care of the type of longitudinal joint.

(5) Fusion welded in accordance with Pars. P-101 to P-111, inclusive.

(6) Sections over 2 inches thick not permitted for pressure parts.

(7) These stresses permitted only with molybdenum.

(8) To these stresses, a casting quality factor of 70 per cent shall be applied. Consideration is being given to rules for inspection and radiographing castings with the view of establishing other quality factors in proportion to the degree of inspection.

(9) These stresses apply to normalized material only.

(10) Not permitted above 450 F; allowable stress 5500 lb per sq in.

(11) These stresses are established from a consideration of strength only and will be satisfactory for average service. For bolted joints where freedom from leakage over a long period of time without retightening is required, lower stresses may be necessary as determined from the relative flexibility of the flange and bolts and corresponding relaxation properties.

(12) Between temperatures of —20 to 400 F, stresses equal to the lower of the following will be permitted. 16 per cent of tensile strength; 20 per cent of yield point stress.

GENERAL:

Carbon steel materials covered by Boiler Code Specifications which are not included in these tables are limited to use at temperatures of from —20 to 650 F. The allowable stress in wrought materials is one fifth of the ultimate; in cast materials, it is one fifth of the ultimate multiplied by the applicable quality factor for design purposes.

Heads flatter than the foregoing limits shall be designed as flat plates.

The use of cast-iron heads shall be limited to the requirements of Par. U-13*g*.

d A cast-iron dished head integral with the cast-iron shell (Fig. U-1 1/2*c*), when a segment of a sphere and subject to pressure on the concave side, shall be designed in accordance with (*c*) but must have a corner radius equal to at least 3 times the thickness of the head. If of semiellipsoidal shape, the provisions of (*c*) for heads of that shape shall apply.

If a cast-iron dished head is so placed as to be subject to pressure on the convex side and the dished portion is not supported by ribs or bracing, the allowable working pressure shall be limited to 0.6 of that permitted when pressure is applied on the concave side.

PAR. U-59*p*(1). Revise to read:

(1) Connections formed by welding a plain-end pipe, welding neck or nipple directly to the vessel without the attachment of additional material, NEED NOT BE STRESS RELIEVED WHERE THE PIPE SIZE IS 3 IN. OR LESS, REGARDLESS OF THE DIAMETER OF THE VESSEL. SUCH CONNECTIONS LARGER THAN 3 IN. PIPE SIZE NEED NOT BE STRESS-RELIEVED PROVIDED the diameter of the opening [of which] does not exceed 10 per cent of the outside diameter of the shell. (Some such connections are illustrated in Fig. U-6*a*, *b*, and *c*.)

PAR. U-66*a*. Revise third section to read:

When an unfired pressure vessel unit consists of more than one pressure chamber operating at the same or different pressures, each such pressure chamber (vessel) WHICH OPERATES AT A PRESSURE ABOVE 15 LB PER SQ IN. shall be subject to the required inspections and hydrostatic tests. THE PART OR PRESSURE CHAMBER TESTED SHALL BE STAMPED SO AS TO INDICATE THAT THE STAMPINGS APPLY ONLY TO THE CHAMBER (VESSEL) TESTED, SUCH AS "JACKETS ONLY," "STOCK SPACE ONLY," ETC.

PAR. U-73*b*. Revise to read:

b EXCEPT FOR PAR. U-68 VESSELS, where vessels are made up of two or more courses with welded longitudinal joints, the joints of adjacent courses shall be SEPARATED BY A DISTANCE OF AT LEAST 5 TIMES THE THICKNESS OF THE THICKER PLATE [not less than 60 deg apart].

PAR. U-141*b*. Revise to read:

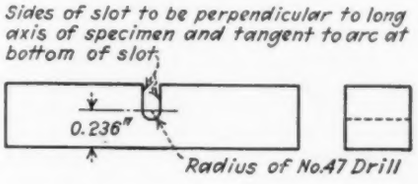
b If of welded construction, containers shall be fabricated in accordance with the requirements of Par. U-68 and in addition, impact tests on the base metal and welds shall meet the requirements of Par. U-142. The number of SUCH impact tests shall be the same as the number of tensile tests required FOR MATERIAL AND SIZE under Par. U-68.

PAR. U-142*c*, *d*, *e*, and *f*. Revise to read:

c Details of Charpy Test. Charpy tests shall be made on a standard Charpy machine using a keyhole OR EQUIVALENT notch specimen as shown in Fig. U-26. The impact properties shall conform to the following:

Charpy impact specimens keyhole OR EQUIVALENT notch	Min impact value ft-lb AT MIN OPERATING TEMPERATURES
10 mm × 10 mm	15
10 mm × 7.5 mm	12.5
10 mm × 5 mm	10
10 mm × 2.5 mm	5

Note: Fig. U-26 is to be revised to show the following "OR EQUIVALENT" specimen in addition to the keyhole notch specimen:



Other dimensions to be as shown by present Fig. U-26. This revision to be shown for specimens of 10, 7.5, 5, and 2.5 mm width.

d Details of Izod Test: Izod tests shall be made on a standard Izod machine using a V-notch specimen as shown in Fig. U-27. The impact properties shall conform to the following:

Izod impact specimens V-notch	Min impact value ft-lb AT MIN OPERATING TEMPERATURES
10 mm × 10 mm	18
10 mm × 7.5 mm	15
10 mm × 5 mm	10
10 mm × 2.5 mm	4

e Number of Impact Tests Required: THE NUMBER OF SPECIMENS TO BE TESTED SHALL BE AS PROVIDED IN PAR. U-141, AND EACH IMPACT TEST SHALL CONSIST OF THREE SPECIMENS EACH OF WHICH SHALL MEET THE MINIMUM REQUIREMENTS. WHERE AN ERRATIC RESULT INDICATES A DEFECTIVE SPECIMEN OR OTHER UNUSUAL CONDITION A RETEST WILL BE ALLOWED.

f [*e*] LOCATION AND HEAT-TREATMENT OF TEST BARS. Impact bars shall be taken in the transverse [and longitudinal] direction from both seamless and welded containers. WHERE TRANSVERSE SPECIMENS ARE IMPRACTICABLE, LONGITUDINAL SPECIMENS MAY BE TAKEN. The required test bars are to be taken from the ends of a seamless container before the shell is thickened for closure, and for the welded containers they shall be taken from the test plates required for each container under Par. U-68. In the case of a welded container one set of impact bars shall be taken across the weld with the notch in the weld metal and one set shall be similarly taken but with the notch in the adjacent metal in the heat-affected zone. All tests are to be run on bars heat-treated in EQUIVALENT SECTION AND in exactly the same manner as are the containers, and bars shall be heat-treated before machining. THE PROCEDURE FOR PRODUCING SUCH BARS SHALL BE SIMILAR TO THAT USED FOR MAKING THE MEMBER.

PARS. H-51 and H-104. Revise to read as follows:

H-51 (H-104). Each steam safety valve shall be plainly marked by the manufacturer in such a way that the markings will not be obliterated in service. The marking may be stamped on the casing, or stamped or cast on a plate or plates securely fastened to the casing, and shall contain the following markings:

(*a*) The name or identifying trade-mark of the manufacturer
(*b*) Size .... in. (the pipe size of the valve inlet)
(*c*) Pressure .... lb (the steam pressure at which it is set to blow)
(*d*) Cap .... lb per hr
(*e*) A.S.M.E. symbol as shown in Fig. H-3½ (to be the same as Fig. P-44).

Permission to use the symbol designated in the foregoing paragraph will be granted by The American Society of Mechanical Engineers to any manufacturer complying with the provisions of the code who will agree, upon forms issued by the Society, that any safety valve to which the symbol is applied will be constructed in accordance with the code and has the capacity stamped upon the valve under the stated conditions, and that he will not misuse or allow others to use the stamp by which the symbol is applied.

A steel stamp for applying the symbol may be purchased by such manufacturers from the Society.

After obtaining the code stamp the manufacturer of valves that are to be stamped with the code symbol shall first submit at least three valves of each three representative sizes of each design for a set pressure of 15 lb per sq in., for testing, together with the drawings, at a place where adequate equipment and personnel is available to conduct pressure and relieving capacity tests, which shall be made in the presence of an authorized observer. The place, personnel, and the authorized observer shall be approved by the Boiler Code Committee.

Qualifying tests shall be made to determine the lift, popping, and blow-down pressures, and capacity at 33⅓ per cent over the 15 lb per sq in. set pressure for each of three representative sizes of each design. A coefficient shall be established for each test as follows:

$$K_d = \frac{\text{Actual steam flow}}{\text{Theoretical steam flow}} = \text{coefficient of discharge}$$

The average coefficient of the tests required shall be taken as the coefficient (K) of the design, and shall be used for determining the relieving capacity of all sizes and pressures of the design in the following formulas:

For 45 deg seat: $W = (51.45 \times \pi\ DLP \times 0.707 \times K)\ 0.90$

For flat seat: $W = (51.45 \times \pi\ DLP \times K)\ 0.90$

For nozzle: $W = (51.45 \times AP \times K)\ 0.90$

where
W = weight of steam per hour, lb,
D = seat diameter, in.,
L = lift, in.,
P = 20 lb gage pressure + 14.7 = 34.7 lb absolute pressure,
K = average coefficient of discharge,
A = nozzle throat area, sq in.

The tests shall be made with steam and in a manner closely approximating actual operating conditions of steam boilers. The relieving capacity shall be measured by condensing the steam or with a calibrated steam flowmeter.

These tests shall be conducted in the presence of, and certified by, an authorized observer.

A data sheet for each safety valve tested shall be filled out and signed by the manufacturer and by the authorized observer witnessing the test. (A sample data sheet report will appear on page 37.) Such data sheet will be the manufacturer's authority to build and stamp valves of corresponding design and construction. When changes are made in the design, similar tests must be repeated.

The relieving capacity that may be stamped on the safety valves shall not exceed 90 per cent of the value determined by the witnessed tests.

All safety and water-relief valves shall be so arranged that they cannot be reset to relieve at a higher pressure than the maximum allowable working pressure of the boiler. The seats and disks of safety or water-relief valves shall be made of nonferrous material.

PARS. H-44 and H-97. Add the following:

Each water-relief valve shall be plainly marked by the manufacturer in such a way that the markings will not be obliterated in service, by stamping or casting on the casing or body of the valve or by stamping or casting on a plate securely fastened to the casing, the letters "A.S.M.E. Standard," the manufacturer's name or trade-mark, and the pressure at which it is set to blow.

PARS. H-53 and H-106. Add the following:

Each boiler is to be stamped to indicate the output at the boiler nozzle at the maximum recommended load. This marking is to be either in pounds of steam per hour or Btu's per hour. 1000 Btu is to be assumed equal to 1 lb of steam.

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of April 5, 1940, which were subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 870 (Reopened)

(*Special Ruling*)

Inquiry: Is it permissible, in the construction of welded fire-tube boilers of types in which the shell plates are not in contact with the gases of combustion, to insert into the cylindrical shell the tube sheets flanged outwardly and welded

to the shell by a circumferential fillet weld which can be stress-relieved but cannot be satisfactorily radiographed? The tube sheet will be supported by diagonal braces and tubes in the same manner as in riveted boilers where tube sheets are commonly inserted with the flange outward and single riveted to the shell.

Reply: It is the opinion of the Committee that a tube sheet flanged outwardly may be inserted in the shell of such a fire-tube boiler and attached thereto by a circumferential fillet weld that is not radiographed, provided:

(1) This joint is wholly within the shell and forms no part thereof;

(2) The throat of the full fillet weld is equal to 0.7 of the thickness of the head;

(3) The construction conforms in all other respects with the requirements of the Code including bracing, type of welding, stress-relieving, etc.

The broad general requirements of Par. P-105 were not intended to apply to this type of construction.

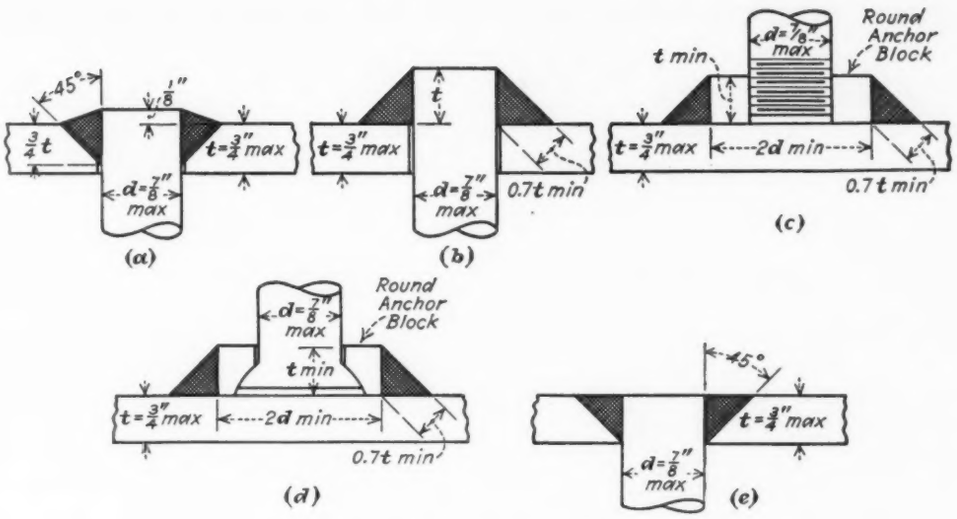


FIG. 37 TYPICAL FORMS OF WELDED STAYBOLTS

CASE No. 881 (Reopened)

(*Interpretation of Table A-6*)

Inquiry: In the revision of Table A-6 recently issued to make it conform with American Standard B16e–1939, the column for flange thicknesses for 150 lb at 500 F in sizes from 1 in. to 3 1/2 in. covers dimensions for loose flanges only and the corresponding dimensions for the integral flanges of valves and fittings were not included. Is it permissible to make use of the differing dimensions for such integral flanges which appear in the American Standard as follows:

Nominal pipe size, in.	Thickness of integral flange, min, in.
1	7/16
1 1/4	1/2
1 1/2	9/16
2	5/8
2 1/2	11/16
3	3/4
3 1/2	13/16

Reply: The dimensions for integral flanges of valves and fittings above given were omitted inadvertently. It was the intent that these dimensions should have been included and it is the opinion of the Committee that they should be used as a part of Table A-6. The dimensions now shown in Table A-6 are intended to apply to loose flanges only, such as blind flanges, screwed, lapped or slip-on companion flanges, welding neck flanges, etc.

CASE No. 896

(In the hands of the Committee)

CASE No. 897

(In the hands of the Committee)

CASE No. 898

(In the hands of the Committee)

CASE No. 899

(In the hands of the Committee)

CASE No. 900

(*Special Ruling*)

Inquiry: May the pressure parts of unfired pressure vessels constructed in accordance with Par. U-69 or U-70 that require support be stayed by means of welded-in staybolts?

Reply: It is the opinion of the Committee that welded-in staybolts may be used in the construction of Par. U-69 or U-70 unfired pressure vessels provided:

(1) The pressure does not exceed 150 lb per sq in.;

(2) The thickness of plate does not exceed 3/4 in.;

(3) The diameter of the staybolt does not exceed 7/8 in.;

(4) The calculated shearing stress does not exceed 6000 lb per sq in., based on the throat dimension of the fillet weld;

(5) The arrangement used conforms to one of those illustrated in Fig. 37;

(6) The provisions of Par. U-40 must be followed using the constant for threaded staybolts.

CASE No. 901

(*Interpretation of Material Specifications*)

Inquiry: Will the use of materials which are outside the limitations as to thicknesses and temperatures given in the title or scope clause of the specifications meet the requirements of the Code if the material is in compliance with the other requirements of the specification, and no similar restriction is given in the rules for construction?

Reply: Such limitations given in the titles and scope clauses of specifications are subject to agreement between purchaser and vendor, and do not limit the use of such materials under Code rules.

CASE No. 902

(*Interpretation of Par. U-13g(3)*)

Inquiry: Par. U-13g(3) stipulates a maximum stress of 2500 lb per sq in. Since Specification S-13 now covers gray-iron castings of 20,000, 30,000, and 40,000 lb per sq in. tensile strength, it is requested that consideration be given to establishing allowable stresses for each of these grades for tension, bending, and compression.

Reply: It is the opinion of the Committee that the following allowable stresses may be used for cast iron furnished in accordance with the requirements of Specification S-13:

Tensile strength, min, lb per sq in.	Maximum allowable working stresses		
	Tension	Bending	Compression
20,000	2000	3000	4000
30,000	3000	4500	6000
40,000	4000	6000	8000

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Legal Aspects of Engineering

LEGAL ASPECTS OF ENGINEERING. By Walter C. Sadler. John Wiley & Sons, Inc., New York, N. Y., 1940. Fabrikoid, 6 × 9 in., 631 pp., $4.

REVIEWED BY J. R. BAKER, MEM. A.S.M.E.

THIS book, embodying the gist of 304 cases adjudicated in the higher courts of the states and nation on subjects related and pertinent to the broad field of engineering, has more than a reference value concerning particular legal rules in which practicing engineers or students may at some time become interested. The book makes no dissimulated pretense of helping the technical isolationist in the solution of his physical and mathematical problems, and at no place in it is there any attempt to delineate the niceties of scientific distinctions with respect to legal determinations. Instead, it sets forth, in an engaging method and on a variety of topical matters, the reasoning which learned jurists have used when reaching decisions on basic subjects in which professional engineers in their relations with clients and other parties are concerned, and of which engineering executives and administrators must be aware. In fact, this reviewer, who does not have the benefit of legal training, cannot imagine a more suitable and enriching pedagogy than a thorough investigation of the contents of this book, for inculcating an understanding of the legal principles which affect the engineering profession and for developing facility in abstract reasoning without which the technician can hardly hope to become an engineering executive or leader in the application of engineering to the complex problems barring man's progress. It is believed that the author has well succeeded in his effort to produce a book of manifold values to the engineering profession.

Although the author in his prefatory remarks evidently considers it to be a casebook compilation, the book is to be distinguished from the kind of casebook ordinarily used by an instructor with a class of law students. It is understood that formal legal educative methods generally employ textbooks which include cases on the same subject with decisions that are apparently contradictory, and similar cases that are supposed to have been decided by different lines of reasoning starting from the same set of facts. Obviously, such casebooks have a special value for the purpose of an analytical coverage of a field in which the student is being guided in his legal development, but they would be liable to confuse and discourage a reader without the benefit of supervisory direction. As far as a limited knowledge indicates, it seems that Dean Sadler's book includes only the so-called "good" law cases; a reader can therefore be assured that when a topical point is treated by a single case, the generally accepted legal principle is exposed.

The 304 cases are arranged in five main groups designated as Professional Problems (76 cases), Industrial Problems (77 cases), Aeronautics (20 cases), Property (66 cases), and Business (65 cases).

Professional Problems are briefly described as those concerning the personal relation of an engineer to his client and work; familiarity with the legal aspects of this relation should be part of the mental equipment of every professional engineer, and it may be predicted that the time is not far distant when state licensing laws will require such competency for registration as an engineer or architect. About one half of the cases in this group arose from disputes directly involving engineers and their duties. The other cases illustrating the legal rules of agency, and ranging over many fields of representation, have no doubt been selected because of their suitability for the purpose of illustration. This is, however, no disadvantage for one will readily perceive that the obligation of an engineer to his principal is no different from that of a business manager to his firm. Interpretation of the statutory law on the subject of registration or licensing of professional engineers and architects is found in eight cases in this group.

In the section on Industrial Problems, the book begins to consider the field of engineering rather than the engineer himself, and to take up matters which are associated more and more with engineering administration as contrasted to the professional conduct of the engineer. Over thirty of the cases in this group are devoted to the subject of Workmen's Compensation. Statutory law in this field is a development of the last 40 to 50 years. The author's notes on how the old common law had to be supplemented to meet changing industrial conditions are noteworthy when attempting to interpret present trends and future possibilities in sociological progress. The handwriting on the wall since the turn of the century as revealed in the law of workmen's compensation is a guide to the future for the engineering administrator who would direct human as well as physical forces. Similar comment may be made in respect of the cases on Nuisances and the public hazards that arose with the widespread distribution of electricity. Preceding these cases are several which emphasize the functions of a special examiner or master and the expert witness in controversies turning upon scientific or technical data; these cases form a logical introduction to the consideration of problems in the engineering field.

The cases on space ownership, aerial navigation, and airports under the heading of Aeronautics form an interlude of modernity between the larger groups of cases on Industrial Problems and Property. On analysis, most of these cases will be found to have an apparent and perhaps real resemblance to others in the book concerning the police power of the state to regulate and abate nuisances, negligence, and liens on property. If by comparison the reader convinces himself that there is a philosophy of law which applies regardless of the superficial aspects of the situation, whether in horse-and-buggy days or in the time of the airplane, he will doubtless discover a stimulating avenue for appreciating the "Legal Aspects of Engineering" and the significance of the law to the engineer.

The section on Property starts with the topic of Mechanics' Liens; this subject is of much interest to owners and their engineering and architectural representatives in business relations with contractors and subcontractors. Like the topics of Waters, Eminent Domain, and Easements, which follow, the law relating to mechanics' liens has had a long history; the first statutory law in this field was enacted in Maryland in 1791. The different

procedures that are possible, and the limited periods in which to seek remedies in the event of unpaid bills for labor and material, have caused the mechanic's lien laws to be strictly construed. One should know for instance that publicly owned and used buildings are not subject to mechanics' liens; that defaults of contractors create express problems that should be speedily recognized; that foresight should be exercised with respect to contractors' bonding.

The nature of the disputes that have arisen about water rights has varied with the locality. Mill rights were the cause of litigation on the streams in industrialized New England; in the West, the use of water for irrigation and mining created many conflicts between different types of users and different users in the same class and gave rise to special statutory law in order to insure an equitable distribution among users. In recent years, the present and future requirements of domestic users in the East have been receiving increasing attention in the long-range planning of water engineers, and recourse to the law to help in the fulfillment of their plans will probably be necessary in certain instances. A knowledge of the subject of Eminent Domain is a prerequisite to such planning.

Building zoning ordinances which end the section on Property are of modern origin in this country; the attention of engineers and architects is being drawn to this field in opposition to the predatory interests of commercial developers and owners forced to economic expedients. Unless the engineer has a firm grasp of the legal circumscriptions of municipal planning, he may find his efforts sometimes frustrated.

The last section of the book, under the heading of Business, includes the standard legal subjects of Contracts and Sales; two thirds of the cases under Business are devoted to these basic topics, whose history reaches back to antiquity. The reflective reader will wonder why most of the cases on Professional Problems, covering the topics of Retaining, Compensation, and Agency, could not also be classed under the heading of Contracts. They no doubt can, for they seem to be merely an application of the principles of Contracts to the particular relation of the engineer and client. Preliminary absorption of the cases on Professional Problems will, however, prepare the reader for any gleaning that may be necessary to enjoy the broader coverage of Contracts.

Interlarded in the section on Business, between the subjects of Contracts and Sales, are several topics which bring down to date the questions of federal and state jurisdiction over inter- and intrastate commerce and of the jurisdiction of the federal labor acts. The influence of tax legislation upon industrial plans is also indicated. There are included several important decisions relating to interstate commerce which have been made in the last few years. The author limited his selection of cases in this field to those involving real commerce or articles intended for commerce. With these cases as a background the reader will be in a better position to appreciate the significance of several cases now in progress, some of an engineering nature, which depend for their federal character, actual or alleged, upon the federal right to protect resources useful for interstate commerce.

The book with its glossary of legal terms, table of cases, and index runs to some 630 pages. One can think of topical subjects not mentioned in it which have an immediate connection with engineers and engineering, such as patent law, property and casualty insurance, regulation of utilities, conservation of resources, and the numerous possibilities of federal activity under a broad interpretation of the general welfare clause of the Constitution. Obviously it would require another book of similar size to include such topics, which the author probably rightly judged to be collateral or subordinate to the more fundamental subjects comprised in his work.

For the benefit of anyone not acquainted with the usual practice in preparing casebooks, the author provides an introductory discussion to each main group and frequently to topical subjects, which sets forth the legal history of and notes the principles illustrated by the following cases. Preceding each case is a statement of the legal points involved which the reader can use to advantage when indexing the case for his particular convenience. The author also furnishes a concise syllabus of each case, so that the reader can quickly come to the kernel of the decision without losing any time in the reading of the introductory and of the nonessential features of the case.

Books Received in Library

ACOUSTICAL SOCIETY OF AMERICA JOURNAL, CUMULATIVE INDEX, Volumes 1–10, 1929–1939. Published for the Acoustical Society of America by the American Institute of Physics, Lancaster, Pa., and New York, N. Y., 1939. Paper, 8 × 10½ in., 131 pp., $3. This work contains author and subject indexes to the first ten volumes of the Journal, as well as to books and papers on acoustical subjects which appeared elsewhere during 1937 and 1938 and were referred to in the Journal.

AERODYNAMIK DER LUFTSCHRAUBE. By F. Weinig. Julius Springer, Berlin, 1940. Cloth, 6 × 9½ in., 484 pp., illus., diagrams, charts, tables, 48 rm. The aerodynamics of the airplane propeller is covered exhaustively, with full mathematical treatment. The general principles are stated, propeller elements are thoroughly investigated, the behavior of the airscrew as a whole is considered, and the relation of the propeller to, and its cooperation with, the airplane itself are fully described. There are a chronological list of reports of tests and a large bibliography.

AIR-CONDITIONING PRIMER, the A-B-C of Air Conditioning. By W. H. Stangle. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1940. Cloth, 6 × 9½ in., 236 pp., illus., diagrams, charts, tables, $2.50. This introduction to air conditioning tells what it is and what it can do, explains its technical fundamentals and the methods of applying them, and describes the many types of equipment available. There are many examples of design computations and some thirty tables of data are appended.

SHORT HISTORY OF SCIENCE. By W. T. Sedgwick and H. W. Tyler, revised by H. W. Tyler and R. P. Bigelow. The Macmillan Co., New York, 1939. Cloth, 6 × 9 in., 512 pp., illus., diagrams, maps, tables, $3.75. This book is based upon one with the same title which was published in 1917, but is to a great extent new. It is based upon lectures given to students at the Massachusetts Institute of Technology. The work provides a readable account of the evolution of scientific thought and knowledge from the dawn of civilization to the end of the nineteenth century, in which the continuity of the development is emphasized. Illustrations from early books and quotations from famous works add to the interest, and there is a useful bibliography.

TURBINES À VAPEUR. By Pio-Oulsky; translated by R. Demchenko and E. Kisselev, preface by C. Monteil. Dunod, Paris, France, 1939. Paper and bound, 8 × 11 in., 403 pp., illus., diagrams, charts, tables, paper, 185 fr.; bound, 210 fr. This text, translated from the Serbian language, represents the course in steam turbines given at Belgrade University. The first section, after a classification by types, discusses in detail the products of the fifteen large European manufacturers. Following this the parts and auxiliaries of steam turbines are discussed from the designer's point of view, and a chapter is devoted to turbine regulation. The final chapter discusses high-speed shafts and their critical speeds. The book is well illustrated.

VDI-FORSCHUNGSHEFT 398, Sept.-Oct., 1939. Die umkehrbare Trennung von Zweistoffgemischen und die Beurteilung von Austauschböden. By H. Mehlig. V.D.I. Verlag, Berlin, Germany, 1939. Paper, 8 × 12 in., 20 pp., diagrams, charts, 5 rm. The reversible rectification of binary mixtures is discussed, including the influence of running temperature and the physical characteristics of the apparatus, with special reference to the rectifier trays. There are numerous equilibrium and other diagrams.

WROUGHT IRON. By J. Aston and E. B. Story. Second edition. A. M. Byers Co., Pittsburgh, Pa., 1939. Cloth, 6 × 9½ in., 97 pp., illus., charts, tables, $1. This little book by two well-known metallurgists is a brief but up-to-date account of the way wrought iron was made, of current methods of manufacture, and of its special properties and main uses.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

A.S.M.E. Three-City Summer Meeting During Week of June 17, 1940

Program Includes 1940 Semi-Annual Meeting in Milwaukee, Wis., June 17–20, and Divisional Meetings in Ann Arbor and Asbury Park

FOR the first time in the history of The American Society of Mechanical Engineers, the 1940 Summer Meeting will be held in three cities at the same time. With simultaneous sessions taking place in Milwaukee, Wis., at the Hotel Pfister, June 17–20; in Ann Arbor, Mich., at the University of Michigan, June 20–21; and in Asbury Park, N. J., at the Hotel Berkeley-Carteret, June 19–22; more members of the Society will be afforded an opportunity to attend the sessions in one of the cities and to take part in the attendant social functions.

Semi-Annual Meeting in Milwaukee

Featured at the 1940 Semi-Annual Meeting in Milwaukee will be 13 technical sessions with 32 papers covering hydraulics, steam power, education and training, management, fuels, machine-shop practice, process industries, and railroads; the semi-annual business meeting of the Society; Council and committee meetings; industrial-plant visits; luncheons; and a banquet. Besides all the events enumerated, visitors will be given an opportunity to play golf and tennis, to go sailing, and to visit points of interest in and about Milwaukee, according to Fred H. Dorner, general chairman of the Meeting Committee.

Another important event to take place in Milwaukee will be the meeting of the A.S.M.E. Nominating Committee, which will hold open hearings at which any member of the Society will be given an opportunity to present names of eligible engineers for consideration. It is expected that the list of the nominees for officers of the Society in 1941 will be ready for public announcement at the banquet on Wednesday evening, June 19.

Other business of the Society will be discussed at the 1940 Semi-Annual Business Meeting to be held on Monday afternoon, June 17, at 1:30 p.m. The Council of the A.S.M.E. urges all members to attend and present their views about Society policy and operation. A meeting of Council members will take place in the morning at 9:30 a.m.

Milwaukee Inspection Trips

Engineers interested in power generation will make a tour of inspection of the world-famous Port Washington power plant on the afternoon of June 17.

Following the general luncheon on Tuesday, June 18, meeting participants will be given an opportunity to make an inspection trip to the Nordberg Manufacturing Company. Preceded by a luncheon tendered by the Allis-Chalmers Manufacturing Company, the visitors will be taken through the company's plant on Wednesday afternoon, June 19. On June 20, an inspection tour will be made at the plant of Kearney & Treacker Co.

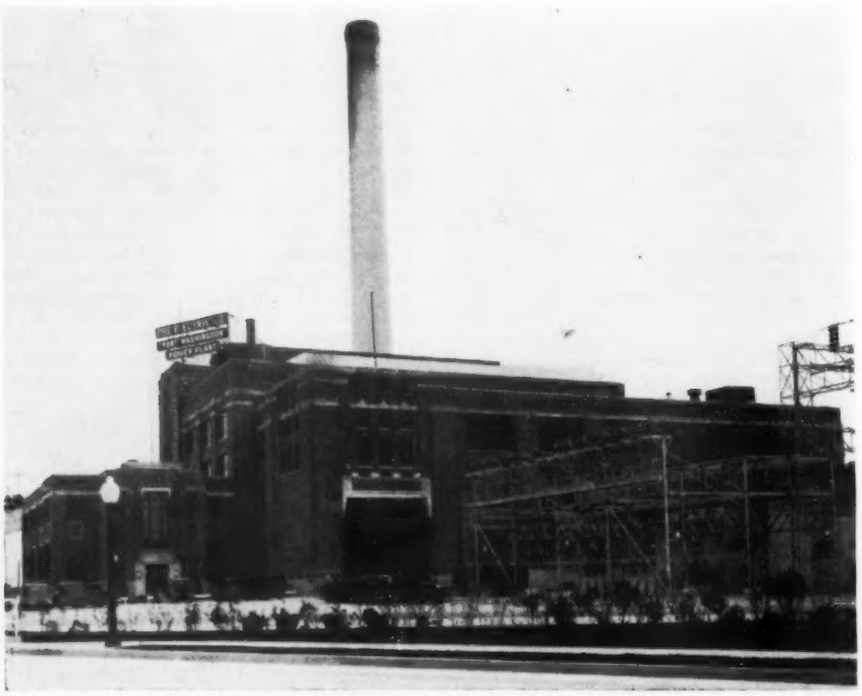
Social Events at Milwaukee

As mentioned before, a general luncheon

Registration Fee for Non-Members at the 1940 Semi-Annual Meeting

There will be a registration fee of $2 for nonmembers attending the 1940 A.S.M.E. Semi-Annual Meeting. For nonmembers wishing to attend just one session the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests may avoid this fee by writing to the Secretary of the Society before June 10 asking for a guest-attendance card for the Semi-Annual Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.



AN INSPECTION TRIP IS PLANNED TO THE PORT WASHINGTON POWER PLANT DURING THE A.S.M.E. SEMI-ANNUAL MEETING IN MILWAUKEE, WIS., JUNE 17–20

(This plant in Milwaukee combines economy of operation with economy of design. It is built on the unit-design principle, and has but one boiler, one turbogenerator, and one set of auxiliaries.)

A.S.M.E. Semi-Annual Meeting Program

Milwaukee, Wis., June 17–20

Headquarters, Hotel Pfister

MONDAY, JUNE 17

9:30 a.m.

Hydraulic—I

Turbulence and Energy Dissipation, by A. A. Kalinske

A Theory of Cavitation Flow in Centrifugal-Pump Impellers, by Calvin A. Gongwer

Power—I

Steam-Turbine Blading, by R. C. Allen

Progress in Design and Performance of Modern Large Steam Turbines, for Generator Drive, by G. B. Warren

Education and Training

Encouragement of Creative Ability, by John E. Ryan and A. R. Stevenson, Jr.

The Employer Suggests Needed Improvements in Our System of Technical Education, by W. H. Carrier

Selection of Men With Creative Ability, by F. Alexander Magoun

1:30 p.m.

Business Meeting to be held in the Main Banquet Room of the Hotel Pfister

2:30 p.m.

Plant trip to Wisconsin Electric Co.—Port Washington Steam Generating Plant

7:30 p.m.

Management

Power and Velocity Developed in Manual Work, by C. A. Koepke and L. S. Whitson

Power—II

Turbine-Blade Fatigue Testing, by R. P. Kroon

Relative "Engine Efficiencies" Realizable From Large Modern Steam-Turbine-Generator Units, by G. B. Warren and P. H. Knowlton

TUESDAY, JUNE 18

9:30 a.m.

Hydraulic—II

An Improved Technique for Centrifugal-Pump-Efficiency Measurements, by R. W. Angus

Economic Draft-Tube Proportions, by A. R. Dawson

Power—III

A Study of Heat-Insulation Problems in Steam Power Plants, by E. T. Cope and W. F. Kinney

Experience With Metals at High Temperatures, by A. E. White

Fuels

Air-Pollution Study, City of Chicago, by Osborn Monnett

Parallel Versus Individual Operation of Multicyclones, by L. C. Whiton, Jr.

Recent Developments in Burning Midwestern Coal in Water-Cooled Stokers, by H. C. Carroll

12:00 noon

General Luncheon

1:30 p.m.

Plant trip to Nordberg Manufacturing Co.

8:00 p.m.

Stag party at Pabst Brewery

WEDNESDAY, JUNE 19

9:30 a.m.

Power and Fuels

The Control of Gases in the Wake of Smokestacks, by R. H. Sherlock and E. A. Stalker

Development of a Major Principle in Pulverized-Coal Firing, by F. L. Dornbrook

Milwaukee's Contribution to Pulverized-Coal Development, by Henry Kreisinger and John Blizard

Machine Shop Practice—I

The Use of Electric-Welded Construction for Columns and Bases in the Machine-Tool Industry, by F. O. Volz

Making Better Machine-Tool Castings, by F. J. Dost

Process

Castor Oil in Lubrication, by Kendall Marsh

Cottonseed Pressure-Cooking Research, by Roscoe W. Morton

1:00 p.m.

Luncheon at Allis-Chalmers Manufacturing Co. with address of welcome by Max W. Babb, president, Allis-Chalmers Manufacturing Co. and later inspection of plant

7:00 p.m.

Banquet, Hotel Pfister

Speaker: George G. Post, vice-president, Wisconsin Electric Power Company, on "Engineering Romance in Milwaukee"

THURSDAY, JUNE 20

9:30 a.m.

Railroad

Symposium on Steam Locomotive Valves and Valve Mechanism

Steam Locomotives—Notes on Ages and Proportions, With Suggestions for Improvements, by J. L. Ryan

Notes on the Trends in Reciprocating Valve Mechanisms Employing Piston Valves, by Chas. F. Krauss

Notes on Valve and Valve-Motion Design for Modern High-Speed Passenger Steam Locomotives, by A. G. Hoppe

Notes on the Measurement of Cylinder Power of High-Speed Steam Passenger Locomotives—Apparatus and Methods, by L. K. Botteron

Train Acceleration and Braking, by R. Clark Jones (to be presented by title)

Machine Shop Practice—II

Hard Facing—a Process for the Mechanical Engineer, by E. E. LeVan

A New Method of Tool and Die Milling, by Francis J. Trecker

12:30 p.m.

General Luncheon

1:30 p.m.

Plant trip to Kearney & Trecker Company

Women's Program for Semi-Annual Meeting

Monday, June 17

4:00 p.m.

Hotel Pfister. Tea and get-acquainted meeting for all local and visiting women

Tuesday, June 18

12:30 p.m.

Luncheon at Milwaukee Yacht Club, followed by card party during the afternoon

8:00 p.m.

Milwaukee Art Institute, 772 North Jefferson Street (one block north of Pfister Hotel), Musicale and Interpretative Dancing. The men are invited

Wednesday, June 19

10:30 a.m.

Public Museum, 818 West Wisconsin Avenue. An entertainment by Dr. Ira A. Edwards and staff comprising a lecture with illustrations on "Wisconsin, the Indians' Arterial Highway Between the Great Lakes and the Mississippi Valley" and a tour in groups, each under direction of staff officer to study life-size Indian groups representing early Wisconsin history

12:30 p.m.

Luncheon at Wisconsin Club (adjacent Public Museum)

1:30 p.m.

Drive through public parks and city

7:00 p.m.

Banquet, Hotel Pfister

Thursday, June 20

2:00 p.m.

Visit to Pabst Brewery

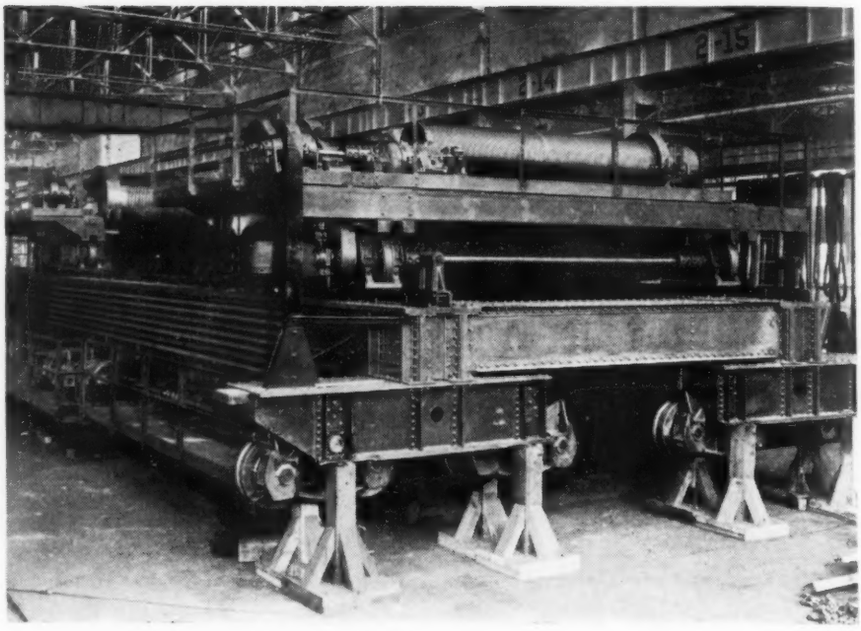
will be held on Tuesday, June 18. The same evening, a stag party is scheduled to be held at the Pabst Brewery with food, drink, and entertainment. Another general luncheon is planned for Wednesday, June 19. The banquet will take place the evening of Wednesday, June 19, in the main banquet room of the Hotel Pfister. Music will be furnished by the Tripoli Chanters. The speakers for the affair include Warren H. McBryde, President of the A.S.M.E., and George G. Post, vice-president of the Wisconsin Electric Power Company, who will speak on the subject, "Engineering Romance in Milwaukee." This should prove especially interesting to the women in the audience.

Women's Milwaukee Program

The women attending the meeting are being provided with a program full of entertainment and interest. Monday afternoon, June 17, a tea and get-acquainted social meeting will be held for all local and visiting women. On Tuesday, luncheon at the Milwaukee Yacht Club will be followed by a card party. In the evening, while the men are at their stag party, the women will be entertained at the Milwaukee Art Institute with a musicale and interpretative dancing. Wednesday morning, Dr. Ira A. Edwards will present an illustrated lecture at the Milwaukee Public Museum. After luncheon at the Wisconsin Club, the visiting women will be taken on a drive through the public parks and interesting sections of the city. Thursday afternoon, all women who are interested will be taken through the plant of the Pabst Brewing Company.

Applied Mechanics Meeting in Ann Arbor

The meeting at Ann Arbor, Mich., under the sponsorship of the Society's Applied Mechanics Division, will present four technical sessions, devoted to elasticity, dynamics, fluid mechanics, and thermodynamics, with 13 papers by some of the outstanding engineering theorists of the country. The program for this seventh national meeting of the Division will be found in MECHANICAL ENGINEERING for May, 1940, page 421. A banquet is also scheduled.



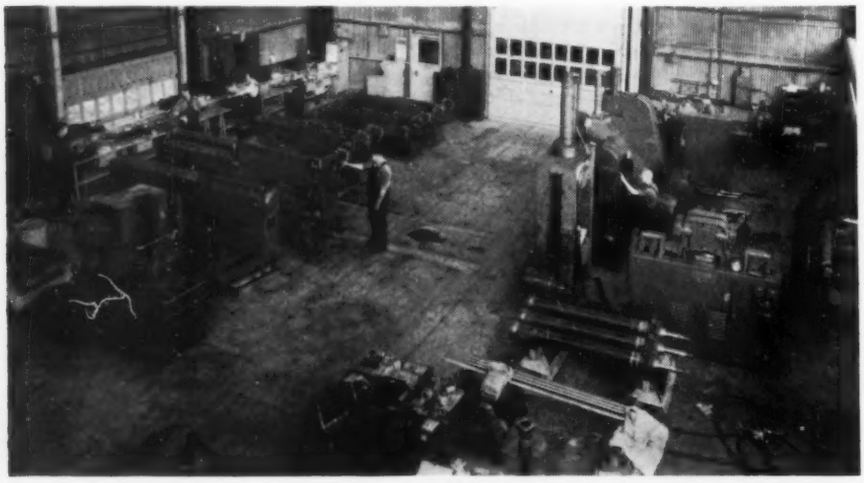
AMONG THE TRIPS PLANNED DURING THE A.S.M.E. SEMI-ANNUAL MEETING IN MILWAUKEE, WIS., JUNE 17–20, IS THAT TO THE PLANT OF THE HARNISHFEGER CORPORATION

(One of the huge 300-ton-capacity power-house cranes such as were installed at Hoover Dam, Bonneville Dam, Pickwick Landing, and elsewhere is shown being assembled on the crane-erecting floor of the Harnishfeger plant.)

Oil and Gas Power Asbury Park Meeting

Besides an exhibit of Diesel Engines and accessories during the four-day meeting, the A.S.M.E. Oil and Gas Power Division's meeting in Asbury Park, N. J., will feature six technical sessions with 12 technical papers on the subjects of Diesel-engine fuels, shaft couplings, marine Diesels, and engine design, operation, and maintenance. A number of plants in the vicinity of Asbury Park, which operate Diesel engines, will be visited during the meeting. Entertainment at the conference will be featured by impromptu radio broadcasting during luncheon and dinner by participating members, and a banquet. Full details of the program for this meeting will be found in the May, 1940, MECHANICAL ENGINEERING, page 420.

As in previous years, there will be a registration charge of $1 for A.S.M.E. members and $3 for nonmembers who attend the Oil and Gas Power Division meeting. This small fee entitles the participant to take part in all of the sessions, to visit the special exhibit, and to receive preprints of the papers being presented at each session, as well as a copy of the Proceedings, which will contain all of the papers together with their discussions.



THE OILGEAR COMPANY PLANT WILL BE VISITED DURING A.S.M.E. SEMI-ANNUAL MEETING IN MILWAUKEE, WIS., JUNE 17–20

(This plant now covers about 70,000 sq ft of floor space. This photograph shows the broach assembly floor. The great increase in speed and efficiency attained by the hydraulic method of broaching splined holes prepared the way for the great spread of surface broaching in recent years. One of the machines for external or "surface" broaching is shown on the extreme left.)

Official Notice

A.S.M.E. Business Meeting

THE semi-annual business meeting of the members of The American Society of Mechanical Engineers will be held Monday afternoon (and *not* evening as announced in the May issue) June 17, at 1:30 p.m. in the main banquet room of the Hotel Pfister in Milwaukee, Wis., as a part of the Semi-Annual Meeting of the Society.

(*Signed*) C. E. DAVIES
Secretary

Spokane, Wash., Ideal for A.S.M.E. Fall Meeting, Sept. 3–6, 1940

Program Will Cater to a Wide Variety of Mechanical-Engineering Interests

THE selection of Spokane, Washington, as the place of the 1940 A.S.M.E. Fall Meeting offers each member of the Society opportunities to enjoy interesting and spectacular technical and recreational experiences. Spokane's location, in the heart of the Northwest, has made it possible to arrange a program catering to a wide variety of mechanical-engineering interests and to allow those in attendance to visit many of the scenic wonders of the nation.

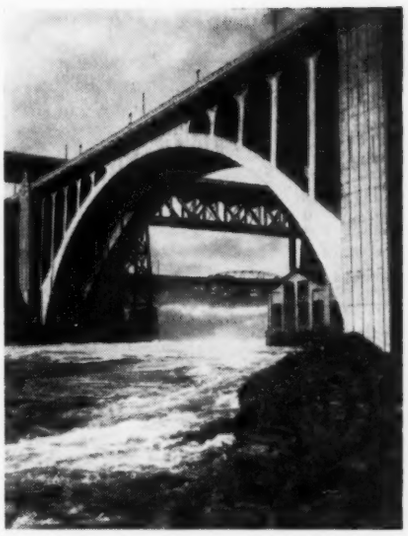
Spokane and Vicinity

Centered around Spokane and within a few hours' drive are located the Coulee Dam, the Coeur d'Alene mining district, the Trail Mine and Smelter of British Columbia, the wood industries and the large soil-erosion and irrigation projects. The Coulee Dam, with its massive structure, 4300 ft long, 550 ft high, and 500 ft thick at the base, is one of the great engineering wonders of the world, and has been a continuous source of attraction to members of the engineering professions. The Coeur d'Alene district contains such famous mines as the Sunshine, the Bunker Hill and Sullivan, the Morning, the Hecla and the rich silver mines of Kellogg and Mullan, Idaho. The wood industries include the large pine mill located on the Clearwater and Snake Rivers, made famous by Lewis and Clark, and the logging operations common throughout the region. Spokane is also the center of the government soil-erosion operations. The Yakima and Wenatchee fruit areas afford a possibility of inspecting the irrigation systems in operation at these famous fruit valleys.

Within 50 miles of Spokane are located 76 lakes and the city is known for its gardens, drives, and parks, including Mount Spokane which offers a beautiful view from its summit 5808 ft high. Within a day's drive are Mount Rainier, Banff, and Lake Louise, and Glacier National Park. For those who can afford a few extra days, the famous Pendleton Round-Up is held the week end after the meeting, and Pendleton is only a one-day drive from Spokane.

Technical Sessions

The technical program includes sessions on hydraulics, wood industries, power and processes, fuels, and heat transfer and management, which will include materials handling. Papers on these subjects have already been submitted and the program committee promises sessions of real interest.



SPOKANE FALLS LOCATED IN CENTER OF CITY

Tour to A.S.M.E. Fall Meeting at Spokane Answers 1940 Travel Problem

August 24–September 14, Period Ideal for Summer Vacation Trip

THE program for the national Fall Meeting of the A.S.M.E., in Spokane, Wash., Sept. 3–6, grows in interest and importance as it develops. It will offer many most unusual opportunities to see such sights as Grand Coulee Dam at a very important stage of its completion—the installation of its mechanical equipment—a visit to the famous Coeur d'Alene mining district and the enormous refinery located there—plus a trip to Lewiston (where Lewis and Clark camped in 1805). Idaho's only "Seaport" with access to the ocean by way of the Snake and Columbia Rivers, Lewiston is the center of a lumbering industry of magnificent proportions. There will be opportunity to visit the large and modern Clearwater Lumber Mill and also the plant manufacturing pressed sawdust briquettes utilizing waste from the lumber industry. There will also be an airplane trip over Grand Coulee Dam and the Great Dry Falls of Washington (three times the dimensions of Niagara Falls) and much of the vast area which will be irrigated by the waters of the Columbia River through the power made available at Coulee Dam.

SPOKANE, WASH., LOOKING EAST

"See America First"

Your trip to Spokane will be enhanced by joining the conducted tour which will take you to some of the most interesting and beautiful spots in America. "See America First" is a necessity in 1940 for those who would travel.

Yellowstone Park Tour and Grand Teton National Park which embraces one of the most precipitous mountain ranges in the world, beautiful in their rugged grandeur, saw-toothed and magnificent, the peaks rise skyward abruptly with practically no foothills

from the relatively level floor of Jackson Hole. Jackson Hole (formerly Jackson's Hole) a valley in early western parlance, is approximately thirty miles in length and 15 miles in width. For a long time this was a hunting ground of the Indians. Dude and real cow ranches abound.

Two-Day Visit to Black Hills

Upon conclusion of the meeting the Tour group will be conducted through the most interesting portions of Glacier National Park including Blackfeet Highway, Hudson Bay Divide, Lower St. Mary Lake and Swiftcurrent Valley, Many Glacier Hotel, Going to the Sun Chalets, spectacular Logan Pass, and beautiful Lake McDonald. After leaving Glacier Park there will be a two-day visit to the Black Hills and the Mount Rushmore Memorial where the faces in high relief of Washington, Jefferson, Lincoln, and Theodore Roosevelt, measuring sixty feet from crown to chin, are being blasted and drilled out of the mountainside with Gutzon Borglum as sculptor. Whereas the work will require years to complete, two, Washington and Jefferson, are now nearing completion.

Early Reservation Desirable

Early reservation for this Tour is desirable and may be made without deposit or financial obligation until thirty days before the trip begins. Use the coupon on page 36 of the advertising section of this issue.

The cost on an all-expense basis (with exception of meals during the meeting) will be approximately $300 depending upon the Pullman space desired.

Metropolitan Women Meet in Home of Horace Greeley

THE spring luncheon of the Metropolitan Section of the Woman's Auxiliary to the A.S.M.E. was held Thursday, May 9, at Rehoboth House, Chappaqua, N. Y., the home of Horace Greeley in 1853, and now the home of Mrs. E. C. M. Stahl, chairman of the Section. Among the things seen were several rare mementos, including the Feb. 6, 1828, edition of the *Northern Spectator*, printed in Poultney, Vermont, and the type case of Mr. Greeley, together with pictures and busts of him.

The National Board held a short meeting at which the president, Mrs. Farny, presided. The Treasurer reported $58.74 in the general fund, $2226.85 in the Educational Loan Fund, and $640 in the Calvin Rice Scholarship Fund, the last being augmented by a $50 contribution from the Metropolitan Section. The Los Angeles Section also sent a contribution of $20 to the National Auxiliary. As a timely aid to recipients of the Loan Fund, the Board reduced the rate of interest on the loans. Since banks demand no more than 2 per cent on loans, the Auxiliary thought it should not ask for a higher rate than banks demand. The Auxiliary took pleasure in congratulating the parent body on its 60 years of splendid work and to place in its records the fine editorial of congratulation in the April 14 edition of the *New York Times*. The meeting then adjourned for luncheon.

Technical Valuation Society Formed

ANNOUNCEMENT has been received of the formation of the Technical Valuation Society, Inc., a nonprofit membership organization incorporated in December, 1939, under the laws of the State of New York. The announcement states that the new society was formed "to meet the urgent need of an organization to discuss the mutual problems of the engineer and the accountant in the field of engineering valuation which at present is in a formative stage."

According to its constitution the new society has the following objectives:

(*a*) To establish the recognition of Valuation Engineering as a professional degree.

(*b*) To promote the intercourse of engineers among themselves and to foster the relations with the accounting branches of valuation work and with official governing bodies.

(*c*) To advance the standards of Valuation Engineering.

(*d*) To foster Valuation Engineering education, and

(*e*) To broaden the scope of the valuation engineer in cooperation with other engineering, technical, and accounting societies.

The officers of the Technical Valuation Society are: L. L. Juretie, Jr., president; R. T. Houseman, treasurer; G. H. Roth, D. C. Alrich, J. D. Fonda, C. F. Pray (Jun. A.S.M.E.), J. F. O'Donnell, and H. Cole (attorney), vice-presidents; and G. A. Rappold, secretary.

Further information may be obtained by addressing L. L. Juretie, Jr., president, Technical Valuation Society, Inc., 60 Wall St., New York, N. Y.

N.A.C.A. Commemorates Its 25th Anniversary

THE National Advisory Committee for Aeronautics commemorated its twenty-fifth anniversary with a reunion luncheon of present and former members on April 18 in Washington, D. C., at the Army and Navy Club. The luncheon followed a reception at the White House by President Roosevelt. The present members, all of whom serve as such without compensation, are: Dr. Vannevar Bush, member A.S.M.E., chairman; Dr. George J. Mead, member A.S.M.E., vice-chairman; Maj.-Gen. H. H. Arnold, U. S. Army; Rear Admiral John H. Towers, U. S. Navy; Capt. Sydney M. Kraus, U. S. Navy; R. H. Hinckley and C. M. Hester, C.A.A.; Dr. C. G. Abbott, Smithsonian Institution; Dr. Lyman J. Briggs, National Bureau of Standards; Dr. F. W. Reichelderfer, U. S. Weather Bureau; Dr. Orville Wright, honorary member A.S.M.E.; Dr. Jerome C. Hunsaker, vice-president A.S.M.E.; Dr. Edward Warner, member A.S.M.E.; and Dr. Robert E. Doherty, president, Carnegie Institute of Technology.

At the reunion luncheon, Dr. Bush announced that, with the approval of the President, the new N.A.C.A. laboratory at Moffett Field, Sunnyvale, Calif., would be named the "Ames Aeronautical Laboratory" in honor of Dr. Joseph S. Ames, chairman of the Committee for 20 years. In making the announcement, it was pointed out that it was under the chairmanship of Dr. Ames that the N.A.C.A. had gained a position of world-wide leadership in aeronautical research.

A.S.M.E. Calendar

of Coming Meetings

June 17–20, 1940

Semi-Annual Meeting
Hotel Pfister
Milwaukee, Wis.

June 19–22, 1940

Oil and Gas Power Division
Hotel Berkeley-Carteret
Asbury Park, N. J.

June 20–21, 1940

Applied Mechanics Division
University of Michigan
Ann Arbor, Mich.

September 3–6, 1940

Fall Meeting
Hotel Davenport
Spokane, Wash.

November 7–9, 1940

Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Hotel Tutwiler
Birmingham, Ala.

December 2–5, 1940

Annual Meeting
Hotel Astor
New York, N. Y.

(*For coming meetings of other organizations see page 22 of the advertising section of this issue*)

Measurement and Control Society Elects New Officers at Meeting

A past vice-president of the A.S.M.E., R. J. S. Pigott, Gulf Research & Development Corp., was elected president for 1940–1941 of The American Society for Measurement and Control at the Society's meeting in Pittsburgh, Pa., April 29, 1940. M. F. Behar, member A.S.M.E., became vice-president; Frank C. McGough was made secretary; C. E. Fry was chosen treasurer; and M. D. Johnson and J. B. Keller were elected directors.

A.S.M.E. Represented at Anthracite Conference

REPRESENTATIVES of the A.S.M.E. at the annual Anthracite Conference, held at Bethlehem, Pa., May 9–10, under the sponsorship of Lehigh University, were Morton M. Price and Sidney T. Mackenzie, Babcock & Wilcox Company, Philadelphia, Pa.

A.S.M.E. 1940 Spring Meeting at Worcester Most Successful

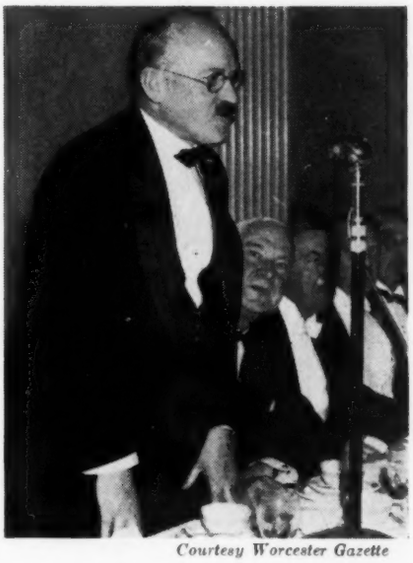
Seven-Point Program to Relieve Unemployment Advanced by R. E. Flanders in His Talk "Progress Report of an Amateur Economist"

NOTHING was left undone by a hard-working committee to make the brief three-day stay of visitors to the 1940 Spring Meeting of The American Society of Mechanical Engineers in Worcester, Mass., May 1 to 3, as pleasant, congenial, and worth-while as was humanly possible. More than 500 members, guests, and wives, some coming from points as far as Toronto, Canada, San Francisco, Calif., and Baton Rouge, La., registered at meeting headquarters in the Hotel Bancroft. From Mayor William A. Bennett of Worcester, Prof. Charles M. Allen, general chairman of the meeting, and Fiske R. Jones, chairman of Worcester Section, to the student members of Worcester Polytechnic Institute, all demonstrated the hospitality and friendship which has made their city known throughout New England and the rest of the United States as "The heart of the Commonwealth." To show the folks who stayed home what they missed, some of the high lights and side lights of the meeting are described in the following paragraphs and pictured in the photographs on this and other pages.

Technical Sessions

More than 800 A.S.M.E. members and guests took part in one or more of the 13 sessions at which 31 authors presented 28 individual or joint technical papers on such subjects as management, merit rating, feedwater treatment, drying, deep-hole drilling, rapid machine motions, atomization of fuel oil, furnace operation, fuels, purity of steam, hydraulics, pressed steel, vapors, specific heats, hydrogen mixtures, materials handling, helical springs, and cavitation research. The most popular session, if number present is any criterion, was the one on Wednesday evening at which 130 heard a paper by G. G. Martinson on the "Successful Mechanical Atomization of Fuel Oil Heavier Than Bunker C," and saw colored motion pictures of furnace operation presented by A. A. Markson, O. F. Campbell, Otto de Lorenzi, A. P. Kratz, and S. Konzo. At a simultaneous session of the Machine Shop Practice Division, more than 100 heard papers on "Automatic Step Drilling of Deep Holes," presented by Eric Hirvonen, and on "High-Speed Photography and the Study of Rapid Machine Motions," given by Victor Sepavich and Albert Palmer and illustrated with motion pictures.

The Metals Engineering Division, formerly the Iron and Steel Division, held a session which was unique and novel because of its being held in the John Woodman Higgins Armory in a setting of medieval armor, ancient battle flags, interesting paintings, and modern pressed-steel products. The high windows and vaulted ceiling of the armory lent a certain enchantment to the meeting, especially when John W. Higgins read his paper in which the use of iron and steel was traced from ancient times to the present, and the prediction was made that the known iron-ore deposits of the world at their present rate of consumption cannot last more than 125 years.



Courtesy Worcester Gazette

RALPH E. FLANDERS, PAST-PRESIDENT A.S.M.E., AND SPEAKER AT THE DINNER AT THE SPRING MEETING, WORCESTER, MASS.

Inspection Trips

Worcester, called by industrialists a "city of diversified industries," provided each participant at the meeting an opportunity to visit plants of particular interest to him. A total of 800 members and guests went on the seven regularly scheduled, and one special, inspection trips. Plants visited included the following:

Norton Company. The president of the company, Aldus C. Higgins, welcomed the visitors by stating that the company, through its founders and their successors and engineers, and The American Society of Mechanical Engineers, through Worcester members and former officers of the Society, have a common tradition, and that the A.S.M.E. members in the company gladly welcome their fellow engineers. The party was given a choice of three tours through the extensive plant. Group one saw the manufacture of grinding wheels and abrasive products, group two inspected the new power plant with its equipment of the most modern type, and group three went through the machine-manufacturing section. At the end of the tours, the visitors were taken to the field house where they were served refreshments and shown a special exhibit of electrical pitching apparatus, stroboscope, reflectometer, Zeiss sandblasting machine, Mullen tester, gas-analysis apparatus, microchemical apparatus, cut-off machines, optical plastic, two of the latest Norton machines, safety equipment used in the plant, and a personnel exhibit.

Courtesy Worcester Telegram

A GROUP AT THE WORCESTER, MASS., A.S.M.E. SPRING MEETING

(Left to right: Fiske Jones, chairman of the Worcester Local Section; Ralph F. Gow, vice-chairman of the general committee; C. E. Davies, Secretary A.S.M.E., Warren H. McBryde, President A.S.M.E.; and Prof. Charles M. Allen, Chairman of the general committee.)

Worcester Spring Meeting in Pictures

[(1) James W. Parker and John F. Tinsley laugh at one of Prof. Charles M. Allen's jokes during General Luncheon. (2 and 3) Part of audience at General Luncheon. (4) Audience at Metals Engineering Division Session. (5) E. E. Jackson and M. D. Engle. (6) John W. Higgins delivering paper. (7) Warner Seely serves ice cream during Banquet. (8) Ralph E. Flanders and Mrs. Harvey N. Davis listen to Charles T. Main. (9) R. E. Flanders, speaker at Banquet. (10) General Luncheon scene shows Mayor Bennett of Worcester, President McBryde, of A.S.M.E., and President Cluverius, of W.P.I. (11) Mr. and Mrs. C. R. Davis, of Toronto, Canada, welcomed by Samuel P. Hunt. (12) George I. Rockwood and Charles T. Main. (13) W.P.I. Quartette entertained at Banquet. (14) President McBryde talks at Banquet.]

Worcester Spring Meeting in Pictures

[(15) During reception at Worcester Art Museum, there was choral singing by the Mendelssohn Singers while (20) the guests were being received by Mr. and Mrs. Paul B. Morgan, President Warren H. McBryde, Dr. and Mrs. Harvey N. Davis, and Mr. and Mrs. Ralph F. Gow (last two not shown). (25) Albert Kingsbury and George I. Rockwood. (16) The women had a grand time. (21, 26, 17, 22, and 27) Scenes at Mrs. F. Harold Daniels' coffee party for the women, including (22) Mrs. Daniels greeting Mrs. Charles M. Allen, and (27) inspection of gem and mineral collection. (18, 23, and 28) At the Rockwood Sprinkler Company's plant, oil, gasoline, and excelsior fires were set to show new types of fire-fighting equipment. (19) W. B. Gurney, C. H. Fellows, E. P. Partridge. (24) A bus load of engineers. (29) Inspection of Higgins Armory.]

MODERN WING, HIGGINS ARMORY, WORCESTER, MASS.

Rockwood Sprinkler Co. In the research laboratory of the plant, latest methods of automatic control of equipment in case of fire were actually demonstrated by the use of fires. The prevention of fires in air-conditioning systems, as well as their detection and control, was shown. Outdoors, an oil fire was put out by a fine spray produced by means of a newly developed water nozzle.

Simonds Saw & Steel Co. Visitors to this plant saw the famous windowless building, five acres in area, in which manufacturing operations are carried on under ideal light conditions and in a controlled atmosphere by which the air in the building is changed five times each hour.

Crompton & Knowles Loom Works. Visitors were shown a very efficient foundry, which has a modern dust-control system, a modern steel workshop with its forging, welding, and pressing operations, a machine shop, a woodworking plant, and several assembly lines on which looms are built.

John Woodman Higgins Armory. At this armory, which is a museum, library, and laboratory of pressed-steel products, housed in a unique steel and glass building, various displays of stamped, cold-forged, and deep-drawn steel products, as well as medieval and ancient armor of knights of old, were shown.

Leland-Gifford Co. Here the visitors saw the mass production of drilling machines of the lighter class, large quantities of which were being manufactured for the export trade, as well as domestic firms, especially those making aircraft and accessories.

Baldwin-Duckworth Chain Co. Visitors at this plant were shown the manufacture of chains and sprockets designed for ammunition hoists on naval vessels, the application of flame hardening as applied to sprockets, die-forging of chain links, and carburization of steel.

Wyman-Gordon Co. The engineers visiting this plant were shown how the company's product of aircraft forgings is tested, inspected, and studied in the research laboratory which contains all types of testing machines.

Heald Machine Co. A special trip was arranged for several A.S.M.E. members who wished to observe the manufacture of internal-grinding machines, the principal product of the company.

Worcester Polytechnic Institute. At this 75-year-old school on the hill, the A.S.M.E. members and guests were taken through the Washburn shops, the aeromechanics laboratory, and laboratories for electrical engineering and electronics, where high-voltage phenomena were demonstrated. The Alden Hydraulic Laboratory, located five miles from the Institute, contains not only complete equipment for hydraulic research but also several fireplaces and some rocking chairs.

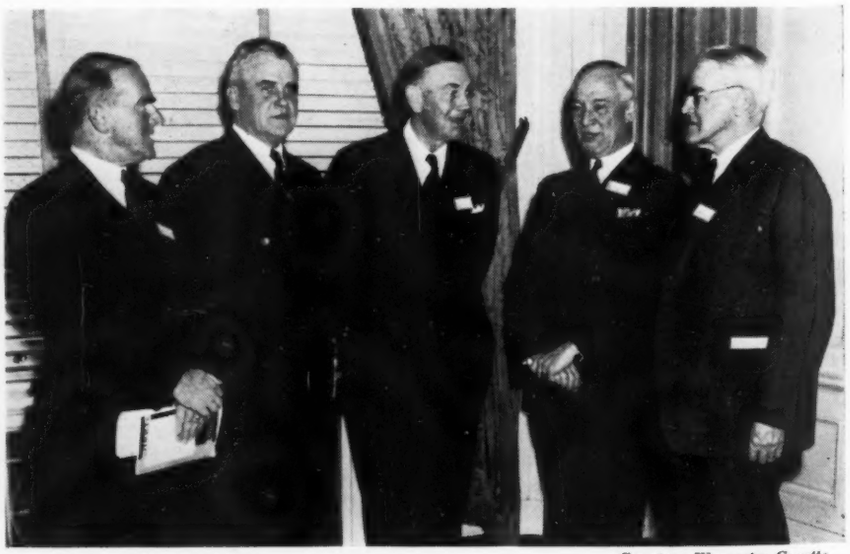
Tribute to Charles M. Allen. Without reflection upon the high quality of the papers and discussion at the hydraulic session, held on Thursday morning at the Alden Laboratory of the Worcester Polytechnic Institute, it may be said that the central figure was Charles M. Allen and the session itself a tribute to him. The papers were devoted to the salt-velocity method of water measurement, developed by Professor Allen, and were written and presented by his own "boys." Professor Allen acted as chairman, host, guide, and raconteur.

It would be difficult to find a laboratory that more richly reflected the personality of its director. The hearty unconventionality of a bluff and friendly genius in which human, scientific, and practical characteristics are engagingly combined is as typical of the laboratory as of the man. Although the audience at the sessions may have been a group of experts in hydraulics, the augmented group of 84 that lunched in the same room at noon was a group of Charlie Allen's friends, attracted there as much by the man as by the occasion. The luncheon was, in fact, a tribute to him just as much as it was his tribute to these friends. Appropriate words of greeting by Professor Allen, President Wat Tyler Cluverius, of Worcester Polytechnic Institute, and President Warren H. McBryde, of The American Society of Mechanical Engineers, enhanced the human friendliness that pervaded the sessions and the environment of the laboratory. Opportunity was afforded before and after the luncheon of inspecting the laboratory and its interesting exhibits and grounds, and the afternoon was given over to a display of motion pictures of model tests.

General Luncheon

More than 300 members and guests were present at the general luncheon which took place on Wednesday, May 1, the first day of the Spring Meeting. Prof. Charles M. Allen, chairman of the general committee, presided in his usual informal manner. After Mayor Bennett had welcomed the Society to the city with a warning to help keep up the fine record of traffic safety by driving not more than 25 mph, Admiral Wat Tyler Cluverius, president of Worcester Polytechnic Institute, greeted the visitors and said that this was not his first contact with engineers because in the boiler and machinery parts of naval ships he had encountered "mechanical engineering afloat." On behalf of the 15,000 members of the Society, President Warren H. McBryde thanked both gentlemen and stated that at the last national meeting of the A.S.M.E. held in Worcester in 1918, Charles T. Main, who was present at the luncheon, presided as president of the Society.

Dr. John F. Tinsley, president of Associated Industries of Massachusetts and of Crompton & Knowles Loom Works, delivered the luncheon address on the topic, "New England Industries, 1940." He expressed a belief that New England will continue to hold its place in industry and will exert its never-failing power of adaptability to new situations. Dr. Tinsley saw a brilliant future for aviation in New England, with more than three hundred



Courtesy Worcester Gazette

BEFORE THE GENERAL LUNCHEON AT A.S.M.E. SPRING MEETING, WORCESTER

(Left to right: John F. Tinsley, President, Crompton & Knowles Loom Works, who spoke on "New England Industries, 1940;" the Honorable William A. Bennett, Mayor of Worcester; Warren H. McBryde, President A.S.M.E.; Admiral Wat Tyler Cluverius, President of Worcester Polytechnic Institute; and Prof. Charles M. Allen, Chairman of general committee.)

Courtesy Worcester Gazette

WOMEN AT JOHN W. HIGGINS ARMORY

(Mrs. John W. Higgins (extreme right) is pictured with three guests at a tea she gave in the Armory. Left to right: Mrs. Ralph F. Gow, chairman of Women's Committee for Worcester Meeting, Mrs. L. P. Alford, and Mrs. Harvey N. Davis.)

New England companies supplying aircraft manufacturers with vital parts. Despite present business conditions, he stated, new industries have been coming into New England where there is a tendency today to decentralize from huge plants in a single industrial area to smaller plants distributed throughout the region and the country.

Reception at Art Museum

Nearly 500 members, guests, and wives were guests on Wednesday evening of the Worcester Section at a reception in the Worcester Art Museum, where there was presented the first public showing of medieval armor recently acquired from the Mackay estate by John W. Higgins, member A.S.M.E., and lent to the museum for the summer. In a thirty-minute lecture, Dr. Martin Graubau, Polaroid Corp., demonstrated how polaroid material could be used in motor vehicles to eliminate headlight glare, and to produce three-dimensional pictures. The effects he produced were startling. A reception followed the lecture. In the receiving line were Paul B. Morgan, member A.S.M.E., and president of the Museum, and Mrs. Morgan; Warren H. McBryde, President of the A.S.M.E.; Ralph F. Gow, vice-chairman of the general committee, and Mrs. Gow; and Dr. Harvey N. Davis, past-president A.S.M.E., and president of Stevens Institute of Technology, and Mrs. Davis. While the guests were being received, there was choral singing by the Mendelssohn Singers of Worcester, a male chorus of 50 voices under the direction of Arvid C. Anderson. Refreshments, consisting of ice cream, cookies, and punch, were served in the Gallery of Frescoes, in which a fine collection of thirteenth-century Italian frescoes were on exhibit. Many of those present spent some time in viewing the magnificent collection of sculptures and paintings, including some by Titian, Whistler, Matisse, and Winslow Homer. Mr. Morgan mentioned the fact that the director of the museum, under whose able direction the collection had been built up, was leaving within a few weeks to become director of the world-famous Metropolitan Museum of Art in New York City.

On the reception committee for the evening were Mrs. R. Sanford Riley, chairman; Mrs. Charles M. Allen, Mrs. Ollison Craig, Mrs. Clarence W. Daniels, Mrs. F. Harold Daniels, Mrs. Orville B. Denison, Mrs. Albert J. Gifford, Mrs. John W. Higgins, Mrs. Forrest F. Lange, Mrs. Frank U. Naughton, Jr., Mrs. Francis W. Roys, Mrs. John W. Sheperdson, Mrs. Franklin G. Treat, and Mrs. Frederick E. Banfield, Jr. Also assisting the committee were George N. Jeppson, George I. Rockwood, past vice-president A.S.M.E., and John W. Higgins.

Banquet

The big social event of the three-day meeting was the banquet on Thursday evening, at which Admiral Cluverius was the toastmaster. He introduced President McBryde, who gave a brief address on the part played by Worcester members and the Worcester Section of the A.S.M.E. in the 60-year existence of the Society. He was followed by C. E. Davies, secretary, who introduced prominent engineers of Worcester and elsewhere who were present, including Charles T. Main, president of the A.S.M.E. in 1918 when another meeting was held in Worcester; George I. Rockwood, who had done so much for the Society; John W. Higgins; Jerome C. Hunsaker, Francis Hodgkinson, and Alfred Iddles, vice-presidents of the A.S.M.E.; Stuart M. Anson, president of the Worcester Engineering Society; Erik Oberg, chairman of the Society's Committee on Meetings and Program; Harte Cooke, chairman of the Old Guard and of the Committee on Professional Divisions; and Warner Seely, chairman of the Committee on Education and Training for the Industries.

A seven-point program to relieve unemployment was advanced by Dr. Ralph E. Flanders, past-president A.S.M.E., and president, Jones & Lamson Machine Co., in the main address of the evening. Speaking on the "Progress Report of an Amateur Economist," Dr. Flanders urged solution of the economic and unemployment problems of the country to prevent what he said was a "distinct danger of revolution." After listing various reasons for unemployment, he gave the following suggestions for control of the problem:

1 Development of the country's employment service to the point where it can give current information on the amount, kind, and location of existing unemployment.

2 Innumerable useful projects prepared in advance so that if unemployment appears, projects will be ready for the immediate employment of the unemployed.

3 Work must be as nearly normal as possible and not used as a means of affecting wages, either up or down, or either for or against unionization.

4 Projects must be noncompetitive with private business, if private business is to be encouraged, to develop initiative for expanding to take up unemployment.

5 Projects must be released by an administrative board under instructions from Congress to match them with the amount, kind, and location of developing unemployment.

6 Expansion of government employment in

Courtesy Worcester Telegram

LOOKING OVER A SUIT OF ARMOR, PART OF COLLECTION ACQUIRED RECENTLY BY JOHN W. HIGGINS, MEMBER A.S.M.E., ARE WARREN H. MC BRYDE, PRESIDENT, C. E. DAVIES, SECRETARY, AND H. N. DAVIS, PAST-PRESIDENT, DURING RECEPTION AT WORCESTER ART MUSEUM

times of unemployment must be accepted by business as being normal and remedial.

7 All government policies with relation to business must be based on the endeavor to expand private employment, production, and consumption.

Dr. Flanders charged the present government with failing to employ "a single one of the essential elements of an effective policy for solving unemployment. The danger to our capitalistic system from uncontrolled unemployment is not a temporary political phenomenon," he asserted. "It is the surface evidence of one of the great ocean currents of history which we cannot reverse or stop but which we can survey and adapt ourselves to. If we treat it in this way, it will bear us to a desired haven.

Prior to the addresses by President McBryde and Dr. Flanders, the audience was entertained with musical selections by the W.P.I. Quartette, consisting of John Morrison, A.S.M.E. student member, Russell Parks, Roger Iffland, and Richard Goulding. The rest of the evening was devoted to dancing.

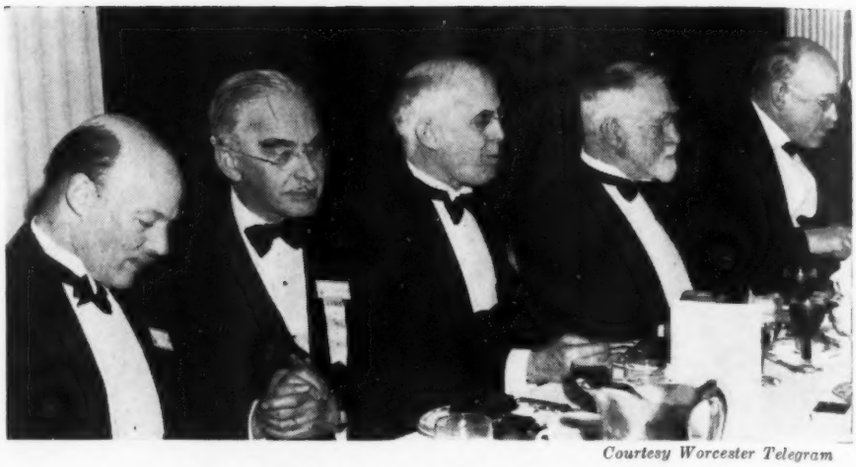
Women's Activities

Members of the women's committee devoted the first day of the Spring Meeting, Wednesday, May 1, to the entertainment of wives and members who came from other cities to attend. Mrs. Ralph F. Gow, chairman of the committee, and her associates established headquarters in the Hotel Bancroft in the morning and welcomed guests as they arrived.

The women were entertained at tea in the afternoon, after a bus trip around the city, by Mrs. John W. Higgins at the John Woodman Higgins Armory. Mr. Higgins gave a short explanatory talk of his collection of armor, and the guests viewed the collection. Mrs. Albert J. Gifford was Mrs. Higgins' cohostess for the tea. Table decorations were small calla lilies, white carnations, and baby's breath. Pourers were Mrs. R. Sanford Riley and Mrs. F. Harold Daniels. In the evening the women took part in the reception at the Worcester Art Museum.

On Thursday, May 2, the women were entertained with luncheon at the Tatnuck Country Club. After luncheon there were games of golf and cards. Despite an invitation in the program to bring their sewing, none of the women present indulged in this domestic pursuit. In the evening, both men and women attended the cocktail hour and banquet.

Friday morning, May 3, all the women went to the beautiful home of Mrs. F. Harold Daniels for a coffee party. After being served coffee by Mrs. R. Sanford Riley and Mrs. Charles M. Allen, who poured, the guests were shown the Harry W. Goddard collection of minerals and gems by Mr. Daniels, who entertained later with several selections on the pipe organ. Of particular interest to all, besides the hundreds of gems, were a flexible sandstone, a zebra-striped sandstone, petrified wood, and gold and silver ore.



Courtesy Worcester Telegram

PART OF HEAD TABLE AT SPRING MEETING BANQUET

(Left to right: J. C. Hunsaker, vice-president A.S.M.E.; George N. Jeppson; George I. Rockwood, past vice-president of A.S.M.E.; Charles T. Main and Ralph E. Flanders, past-presidents A.S.M.E.)

Committee Members

The credit for putting on this splendid program goes to the Worcester members and their wives who worked very hard to make it one of the best Spring Meetings ever held by the A.S.M.E. All those who attended will long remember the wonderful New England hospitality extended to them by Prof. Charles M. Allen, chairman, Ralph F. Gow, vice-chairman, and the members of the General Committee and subcommittees, which consisted of: *Registration, Hotels, and Entertainment*, Orville B. Denison, chairman, Kenneth B. Merriam, Forrest F. Lange, Frank U. Naughton, Jr., Bertram A. Hildebrandt, and Arthur D. Putnam; *Technical Program*, Robert P. Kolb, chairman, Albert Palmer, Gleason H. MacCullough, C. W. Hubbard, and Wilbur Searle; *Finance*, Albert J. Gifford, chairman, George N. Jeppson, and Paul B. Morgan; *Reception*, F. Harold Daniels, chairman, F. E. Banfield, Jr., Ollison Craig, H. Clayton Kendall, Paul B. Morgan, G. M. Pomeroy, George I. Rockwood, John W. Higgins, J. W. Sheperdson, Francis W. Roys, Clarence W. Daniels, and Carleton A. Reed; *Plant Visits*, Clifton P. Howard, chairman, H. E. Howard, Raymond Tolman, Robert Erickson, John Doyle, A. L. Wilkinson, Edward K. Allen, Jr., John Brand, Joseph Pepin, Gleason H. MacCullough, Clyde W. Hubbard, and Howard P. Crane; and *Publicity*, Robert Erickson, chairman, Warren S. Snow, Russell H. Wood, and Edward K. Allen, Jr.

Women's Committee

The Women's Committee was made up of Mrs. Ralph F. Gow, chairman, Mrs. O. B. Denison, Mrs. F. Harold Daniels, Mrs. R. Sanford Riley, Mrs. John W. Higgins, Mrs. Albert J. Gifford, Mrs. Frank U. Naughton, Jr., Mrs. F. E. Banfield, Jr., Mrs. Charles M. Allen, Mrs. George I. Rockwood, Mrs. Robert P. Kolb, and Mrs. Clarence W. Daniels.

ON AN INSPECTION TRIP TO THE PLANT OF THE NORTON COMPANY, WORCESTER, MASS.

A.S.M.E. Receives "The Golden Album of Puerto Rico"

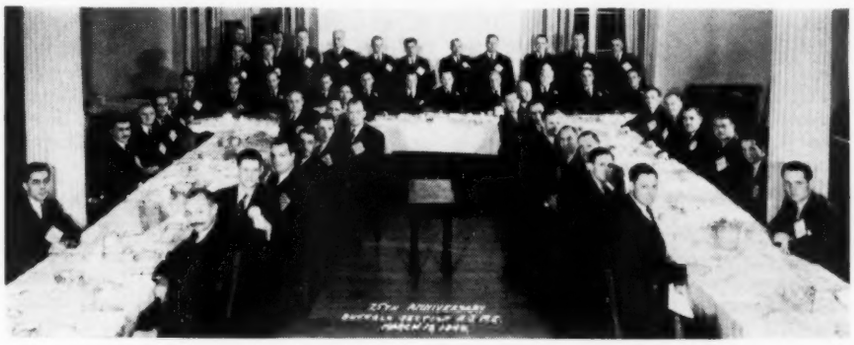
ONE of the best collections of articles and pictures of Puerto Rico, organized and published as "The Golden Album of Puerto Rico," was presented recently to the A.S.M.E. with the compliments of the government of Puerto Rico, Department of Agriculture and Commerce, through the commissioner, Isidoro A. Colón.

The book has been placed in the reading room at Society headquarters where it may be used by A.S.M.E. members.

Nation-Wide Meetings in April Celebrate 60th Anniversary of A.S.M.E. Founding

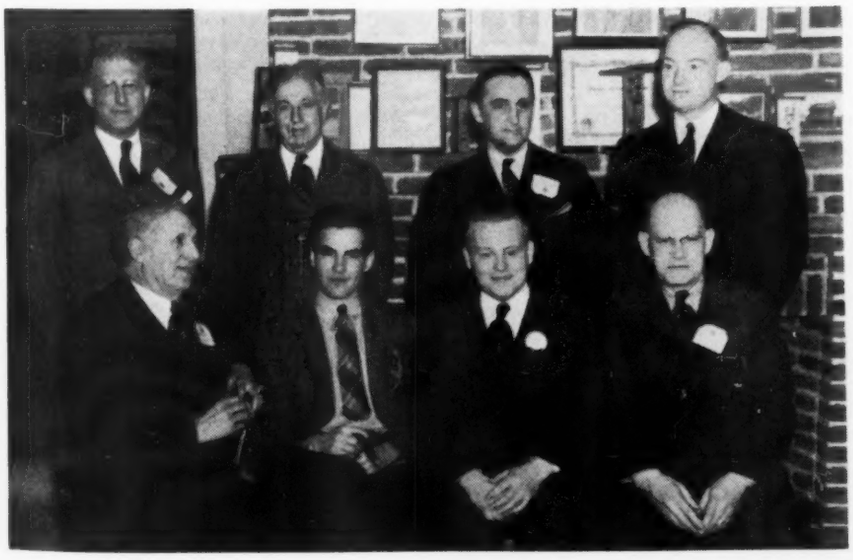
Thousands of Mechanical Engineers Take Part in Local Section Observances of Society's Birthday and Review Service to Industry and Public

EAST and west, north and south, the majority of the 71 Local Sections of The American Society of Mechanical Engineers were holding special meetings in April to observe the founding sixty years ago of the parent Society and to rededicate the 15,000 members to the aims and objectives formulated by the founders. In line with this thought, President Warren H. McBryde in a special message to the officers of all Local Sections stated: "More than ever before, the Society and its Local Sections should be mindful of their duty and responsibility in the field of technological development of mechanical engineering as a profession. The membership should be more definitely impressed and keenly alive to the problems that concern the profession and to their opportunity to assume a place in the economic and social sciences."



TWENTY-FIFTH ANNIVERSARY OF A.S.M.E. BUFFALO SECTION, MARCH 19, 1940, AND 60TH ANNIVERSARY OF SOCIETY

Urging greater cooperation among Local Sections and members, C. E. Davies, Secretary of the Society, said, "As a member of the sixty-year-old A.S.M.E., you are part of a great organization which is founded and maintained upon democratic principles. The officers of the Society and of your Local Section are members elected to their offices by you. Their work would be fruitless without the whole-hearted cooperation of every member. Therefore, our past achievements should more than ever instill in each of us a greater urge for increasing the influence of the engineer upon the well-being of mankind and the enrichment of life." A. J. Kerr, chairman of the Committee on Local Sections, in his message to Local Sections upon the occasion of the sixtieth anniversary concluded by saying, "Changing conditions are placing greater responsibilities upon the Society and the mechanical-engineering profession. Therefore, in order to help advance our standing in the community and the nation, each of us should resolve at this time to develop further the resources of our Society, utilize to the full its powers, build up its activities, promote all its great interests, and see whether we of this generation and age may not also perform as great things as the founders and past members of the A.S.M.E."



ANTHRACITE-LEHIGH VALLEY SECTION CELEBRATES A.S.M.E. SIXTIETH ANNIVERSARY WITH SMOKER AT SUNSHINE CLUB OF BETHLEHEM STEEL CO.

(*Seated*, left to right: R. H. Porter, master of ceremonies; Jack McQuillan, chairman of Student branch at Lafayette; Robert Corby, chairman of Student branch at Lehigh; P. B. Eaton. *Standing*, left to right: K. M. Irwin, vice-president A.S.M.E.; Harte Cooke, past vice-president A.S.M.E.; D. G. Williams; and J. R. Connolley, chairman of the committee arranging the meeting.)

Anthracite-Lehigh Valley Section

As part of the nation-wide observance of the sixtieth anniversary of the A.S.M.E., the Anthracite-Lehigh Valley Section held a smoker on April 11 at the Bethlehem Steel Company's clubhouse in Bethlehem, Pa. More than one hundred members and student members from Lehigh University and Lafayette College were present to listen to such able speakers as Harte Cooke, K. M. Irwin, Prof. P. B. Eaton, and Roy Porter, who proved to be a splendid master of ceremonies.

The following night, April 12, another meeting was held in Pottsville, Pa. Despite a heavy snowstorm and icy roads, about 30 members came to listen to Dr. E. J. Abbott, who talked on the subject of quieting machinery with the aid of sound measurements.

Baltimore Section

Several hundred members attended the April 10 meeting of the Baltimore Section to celebrate the sixtieth birthday of the parent Society. Henry H. Snelling, of Washington, D. C., spoke at the dinner preceding the meeting on the history and growth of the A.S.M.E. since it was formed April 7, 1880, at Stevens Institute of Technology. Several local engineers who have been members of the Society almost since its inception were present. At the meeting which followed, Dr. E. J. Abbott gave an interesting paper on sound measurements and their application to industrial problems.

Bridgeport Section

The meeting of the Bridgeport Section on April 25, observing the sixtieth anniversary of the A.S.M.E., was held under the auspices of the Junior Group. After the presentation of a short history of the Society, the Local Section, and the Junior Group, the speaker of the eve-

ning, Franklin M. Gates, member of the Rocket Club of Connecticut, was introduced. His talk on "The Development of Rockets and Their Future" proved highly interesting, particularly when it was mentioned that the U. S. Army is conducting experiments with rockets.

Buffalo Section

Buffalo Section started the ball rolling in the nation-wide celebration on March 19 with a special Sixtieth National and Twenty-Fifth Section Anniversary Meeting which was attended by almost 100 members, including many past-chairmen of the Section. The speaker of the evening, Harte Cooke, was introduced by J. L. Yates, who acted as toastmaster. Mr. Cooke reviewed 27 years of pioneering Diesel-engine research and progress by discussion and illustrations.

Central Indiana Section

About 160 members and guests attended the sixtieth anniversary celebration by the Central Indiana Section in the Indianapolis Auditorium on April 23. In keeping with the times, Dr. J. J. Harrany gave an address on "The Why of the Second World War." The meeting attracted so much attention that the *Indianapolis Star* in an editorial showed how the A.S.M.E. and the Local Section had assisted industry and the public.

Central Pennsylvania Section

Meeting at State College, Pa., the Central Pennsylvania Section observed the sixtieth anniversary of the A.S.M.E. with a meeting on April 11. After several of the officers paid tribute to the parent society, the speaker of the evening, Dr. E. J. Abbott, described, to the audience of 72, different methods of quieting machinery.

Charlotte Section

The program of the A.S.M.E. meeting in Winston-Salem, N. C., April 19, consisted of a dinner at which papers on the chemical principles of water treatment were presented by Dr. E. E. Randolph, North Carolina State College, and Dr. Marcus Hobbs, Duke University. After a period of entertainment, the audience of 85 heard a paper by C. L. Crockett, N.&W. R.R., on the subject of "Practical Feedwater Treatment." The discussion was followed by a tour through the plant of the R. J. Reynolds Tobacco Company.

Cleveland Section

At the meeting of the Cleveland Section on April 11, more than 100 members and guests heard papers on the very timely topic of "Industrial Preparedness and National Defense," presented by Col. Harry K. Rutherford, director of the planning branch, Ordnance Department, U. S. Army, and Maj. David N. Hauseman, attached to the office of the Chief of Ordnance.

Detroit Section

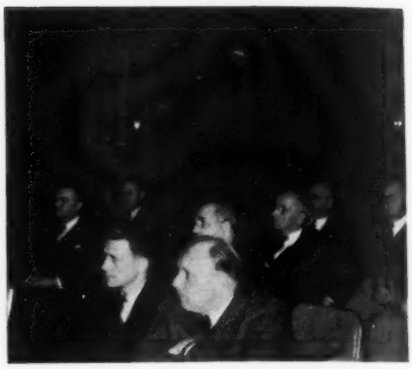
Appropriate observance of the sixtieth anniversary was made by the Detroit Section at its annual meeting, held on May 7, at the General Motors proving ground at Milford, Mich. Restricted to members and student members from the University of Michigan, University of Detroit, and Michigan State College, the meeting attracted several hundred. After the inspection of the facilities of the proving ground and a dinner, William H. Manning, test engineer, Pontiac Motor Division, gave a paper on "Dynamic Roadability Tests."

Florida Section

As part of the twenty-fourth annual meeting of the Florida Engineering Society in Hollywood Beach, Fla., April 11–13, the Florida Section celebrated the sixtieth anniversary of the Society and the fifteenth anniversary of the Section at a special session on Friday afternoon, April 12. Papers were presented by Dean W. R. Woolrich, W. A. Lawrence, F. K. Fischer, and J. T. Legget.

Greenville Section

At its celebration on April 22, the Greenville Section was fortunate in having as its guest speaker none other than Warren H. McBryde, President of the A.S.M.E. In citing recent improvements in transportation, communication, and industrial methods, he urged his audience to observe the various factors influencing the change of the course of the mechanical-engineering profession.



SPRING ROUND-UP TECHNICAL SESSIONS WERE INTERESTING

Ithaca Section

Meeting in Binghamton, N. Y., on April 16, the Ithaca Section observed the sixtieth anniversary of the Society with a record audience of more than 200. The speaker of the evening, Lauren D. Lyman, gave a paper on "Aviation in Peace and War."

Los Angeles Section

Despite very hot weather, more than 100 members turned out for the April 11 meeting of the Los Angeles Section. Thirty "old timers" of the 87 in the Section were present together with the first Section chairman, Col. W. H. Adams, and the first secretary, Ford Harris. The oldest member present was C. V. Kerr. The speaker of the evening, King Hathaway, gave a very interesting history of the Society leading up and through the early stages of scientific management to the present, including a discussion of present methods and results and possibilities for the future.

Louisville Section

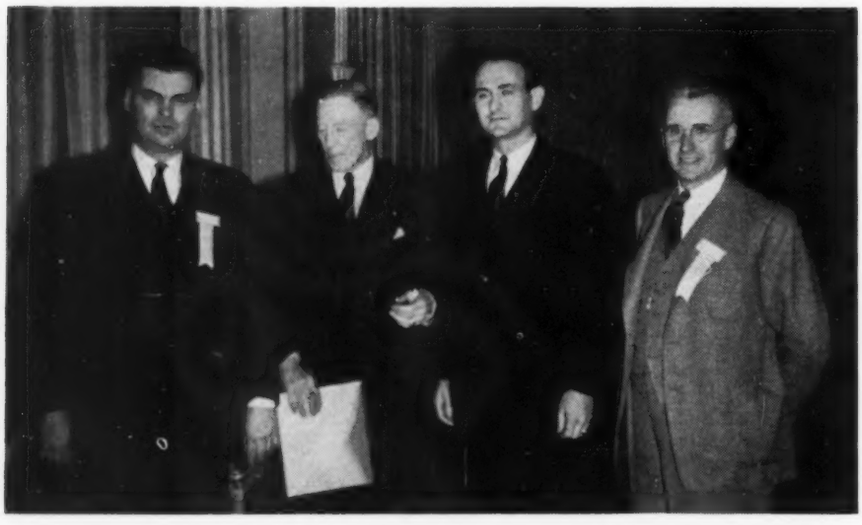
In honor of the occasion, the Louisville Section invited the Louisville Engineers and Architects Club to participate in the meeting on April 16. Howard C. Murphy, vice-president, America Air Filter Co., gave a paper on "Trade Possibilities in South America."

Memphis Section

A special dinner was held on April 10 at which E. W. O'Brien, past vice-president A.S.M.E., was the guest of honor. He spoke about the history of the Society for the last sixty years.

Metropolitan Section

The sixtieth anniversary of the Society was celebrated by the Metropolitan Section in conjunction with its second annual "Spring Round-Up," which was held at the Hotel Astor on April 25. At the technical session, in the afternoon, which was presided over by Howard C. Coonley, chairman of the board, National Association of Manufacturers, papers were presented by Charles J. Stilwell on



SPRING ROUND-UP PERSONALITIES INCLUDED W. H. LARKIN, COL. FRANK P. LAHM, AIR CORPS, U. S. ARMY, CAPT. DANIEL J. MARTIN, ORDNANCE DEPT., U. S. ARMY, AND PROF. F. D. CARVIN

FUN AT THE SPRING ROUND-UP OF THE A.S.M.E. METROPOLITAN SECTION

"Manufacturing Keeps Pace With National Defense," R. C. Roe on "Power—a Vital Factor of National Defense," Capt. Daniel J. Martin, U. S. Army, on "Munitions and Defense," Col. Frank P. Lahm, U. S. Army, on "Air Transportation and the National Defense," and Harold V. Coes on "Educational Orders for Peacetime Production."

In the evening, more than 600 members and guests sat down to dinner, at the end of which Warren H. McBryde, President of the Society, gave a brief talk on the history and responsibilities of A.S.M.E. Following this, Frank W. Smith, past-president, Consolidated Edison Co. of N. Y., acting as master of ceremonies introduced a series of outstanding vaudeville and radio artists who provided excellent entertainment.

Mid-Continent Section

April 15 was the date selected by the Mid-Continent Section to celebrate the sixtieth anniversary of the A.S.M.E. Guest and speaker of the evening was Eugene W. O'Brien, past vice-president of the Society.

New Orleans Section

The sixtieth anniversary of the A.S.M.E. was celebrated by the New Orleans Section on April 8 with a dinner, followed by a joint meeting with the Louisiana Engineering Society. Present at the dinner were President Warren H. McBryde, Dean W. R. Woolrich, and Joseph W. Eshelman, manager of the Society. At the meeting, Dean Woolrich gave a paper on "Quick Freezing." After the lively discussion which followed, President McBryde spoke on the history of the A.S.M.E. and the opportunities for the engineer today. According to George R. Hammett, secretary-treasurer of the Section, this was one of the finest meetings ever held by the Section, being attended by more than 200 members and guests.

North Texas Section

The April 11 meeting was a joint enterprise of the North Texas Section and the Southern Methodist University Branch of the A.S.M.E. Papers were presented by the following student members: V. C. Schumacher, W. F. Riddle, Cecil Turquette, Charles Grimes, and Raymond Holland.

Norwich Section

The sixtieth anniversary meeting of the Norwich Section was held at the University of Connecticut and attended by 36 members and guests, despite a heavy rainstorm. Following an inspection of the new engineering building on the campus, Dean Edel reviewed the aims and objectives of the Society, L. D. Whiton, senior member in the Section, discussed the problems of the young engineer, and C. H. Chatfield, director of research, United Aircraft Corp., talked on the design of modern aircraft.

AT THE DINNER OF THE SECOND ANNUAL SPRING ROUND-UP OF THE A.S.M.E. METROPOLITAN SECTION, HOTEL ASTOR, NEW YORK CITY, APRIL 25, CELEBRATING ALSO THE SIXTIETH ANNIVERSARY OF THE SOCIETY

Engineers Mark Sixtieth Year

Toledo Joins With Rest of Nation in Celebrating Anniversary

Members of the Toledo section, American Society of Mechanical Engineers, are joining this week with the 70 other local sections throughout the country to celebrate the 60th anniversary of the founding of the organization

Mechanical Engineers Mark Society's 60th Anniversary

Group Planning Dinner Thursday Cites Ethical Accomplishments.

Bridgeport engineers are observing this week the 60th anniversary of the founding of the American Society of Mechanical Engineers, an organization responsible for many of the codes and standards by which American industry today is governed.

60TH BIRTHDAY OF ENGINEERING SOCIETY NEARS

Members of Buffalo section to join national observance of founding on Tuesday

Marking the 60th anniversary of the founding of the American Society of Mechanical Engineers at the Stevens Institute in Hoboken, N. J., on April 7, 1880, the Buffalo section of the national group will join with 1,500 members and 6,000 student affiliates throughout the nation in commemorating the event. The Buffalo unit also will observe the 25th anniversary of its creation.

Valley Section Marks 60th Year Of Society Life

Mechanical Engineers Hear Address By Harte Cooke

The Anthracite-Lehigh Valley Section of the American Society of Mechanical Engineers, last night joined in the celebration of the 60th anniversary of the national organization by holding a smoker at the Bethlehem Steel Company clubhouse, near Bethlehem

A. S. M. E. Makes 60th Anniversary Celebration Plans

Mechanical engineers of the United States and Canada will observe during April the sixtieth anniversary of the founding of the American Society of Mechanical Engineers.

The South Texas section of the society will hold its anniversary meeting in Houston April 5. Warren H. McBryde, consulting engineer of San Francisco and president of the A. S. M. E., will speak, Joe J. King, section chairman, said.

Engineers to Mark Anniversary

The sixtieth anniversary of the founding of the American Society

Mechanical Engineers To Mark Anniversary

Dinner Slated Wednesday In Observance Of Group's 60th Birthday

Members of the Waterbury section, American Society of Mechanical Engineers, will sponsor a dinner Wednesday night at 6:15 o'clock in celebration, of the national society's 60th anniversary.

Engineer Group Marks Founding

The Central Indiana Section of the American Society of Mechanical Engineers will observe the sixtieth anniversary of the society's founding Tuesday at 8 p. m. in the World War Memorial building.

Mechanical Engineers To Observe Anniversary

The Norwich section of the American Society of Mechanical Engineers will celebrate the tenth anniversary of its founding and the 60th anniversary of the national body this week at the University of Connecticut.

A. S. M. E. MARKS 60TH BIRTHDAY WITH BANQUET

Avery New Chairman; Hydraulic Power Discussed

An analysis of hydraulic power transmission was presented by three engineers last night at the monthly meeting of Rock River section, American Society of Mechanical Engineers, at the Faust hotel. More than 50 engineers from Rockford, Beloit and Madison attended the dinner session, at which the 60th anniversary of the A. S. M. E. was observed.

Engineering Society to Note Anniversary

Members of the Schenectady section of the American Society of Mechanical Engineers will join with mechanical engineers throughout the United States and Canada this month in observing the 60th anniversary of the founding of the organization which has 15,000 members in 71 local seations in various industrial areas.

The New York Times
Reg. U. S. Pat. Off.
"All the News That's Fit to Print."
ADOLPH S. OCHS, Publisher 1896-1935.
Published Every Day in the Year by THE NEW YORK TIMES COMPANY.
ARTHUR HAYS SULZBERGER, President and Publisher.
JULIUS OCHS ADLER, Vice President and General Manager.
GODFREY N. NELSON, Secretary.
SUNDAY, APRIL 14, 1940.

ENGINEERING CELEBRATION

Sixty years ago this month a group of mechanical engineers met at Stevens Institute of Technology in Hoboken and organized the American Society of Mechanical Engineers. Hence the celebration in which seventy-one sections of the society are now participating. From an initial 180 the membership has grown to 15,000, with an influence on public affairs that citizens everywhere should hail.

After Andrew Carnegie provided the fine building in New York for the engineering societies as a group and the late, beloved and energetic Calvin W. Rice became the secretary of the mechanical engineers, the society flowered and became an institution with which we could hardly dispense. If boiler explosions are now rare it is because of a boiler code which the society framed and which has been incorporated in the laws of twenty-four States. Similar codes were developed for elevator, compressed-air machinery, pressure piping and conveying equipment, with beneficent results. Nearly every piece of machinery has been the subject of searching inquiries, which are now respected by manufacturers. Especially important is the attention that has been paid latterly to the human aspects that envisage the engineer as a molder of society, with grave social responsibilities.

We have only to look back at the history of the organization to be reminded once more of the ability of the technically trained professions to serve as voluntary guides of a democracy which has recently displayed too great a willingness to let local and Federal Governments direct its affairs. If the machinery of this country—and we mean literally its power-driven mechanisms—runs as smoothly and safely as it does, we have the American Society of Mechanical Engineers to thank not only for the quiet, efficient way in which it has met its obligations, but for the proof that it has given of free enterprise's ability to adjust itself to the demands of a new economy.

60th Year to Be Celebrated April 23 By Society of Mechanical Engineers

The 60th anniversary of the American Society of Mechanical Engineers will be observed by the Central Indiana section at 8 o'clock the night of April 23 in the India

Professor John J. Haramy of Indiana Central College, will speak on "The Way of the Present World War."

Baltimore Section Of American Society To Give Dinner Tomorrow

The Baltimore section of the Amer-

SOME PRESS CLIPPINGS ON A.S.M.E. SIXTIETH ANNIVERSARY CELEBRATION

Ontario Section

Canada, in the person of the Ontario Section, paid tribute to the 60-year old A.S.M.E. at a meeting on April 11 at which members of The Institution of Mechanical Engineers (Great Britain) were guests. The history of the Society and activities of the Section were duly presented to the large gathering. Prior to a talk by O. F. Campbell, Sinclair Refining Company, on "Industrial and Domestic Fuel-Burning Problems and Applications," a movie short, "Finland Fights," was shown.

Oregon Section

More than 150 members and guests of the Oregon Section were present at the March 29 meeting. A brief review of the history of the A.S.M.E. was given by Paul Heslop. Then, "Problems of Conductor Vibration" were discussed by Charles R. Boyle, Walter Hays, and F. S. Smith, all of the Aluminum Company of America. A series of films on the subject followed.

Philadelphia Section

The Philadelphia Section celebrated the sixtieth anniversary of the founding of the A.S.M.E. with a luncheon at the Engineers Club on April 11. All living past-chairmen since the founding of the Section were invited. All responded and 16 were present, including T. C. McBride, first chairman and instigator of the Local Section idea. The large group of 106 was addressed by K. M. Irwin, vice-president of the A.S.M.E., who discussed the financial setup of the Society.

Pittsburgh Section

About 75 members and guests were present at the March 28 meeting of the Pittsburgh Section in honor of the anniversary of the A.S.M.E. N. B. Hudson, General Electric Co., gave a paper on the "Double Automatic Extraction Turbine."

Plainfield Section

Meeting in Elizabeth, N. J., on April 16, the Plainfield Section paid tribute to the parent Society on its anniversary. H. L. Husson, superintendent of manufacturing engineering, Western Electric Co., gave a lecture on "The Problems of a Changing Population."

Providence Section

At a special meeting on April 12 in commemoration of the founding of the A.S.M.E., the Brown University Student Branch was given an opportunity by the Providence Section to present to the Providence Engineering Society a framed portrait of Robert Henry Thurston, who, according to the brass plate attached to the frame, was "Engineer—Inventor—Educator—First President and Founder of the A.S.M.E." After a tribute to this great man by Dr. Adams, a vivid picture of the early members of the Society was given by Harte Cooke.

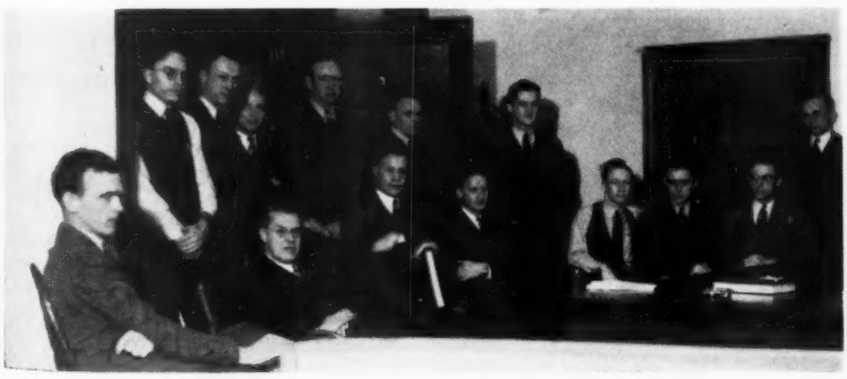
A.S.M.E. ST. LOUIS SECTION 60TH ANNIVERSARY DINNER, ALGONQUIN GOLF CLUB, APRIL 12, 1940

Rock River Valley Section

More than 75 members and guests took part in the April 18 meeting of the Rock River Valley Section in Rockford, Ill. Hydraulic power transmissions were discussed by Walter Ferris, chief engineer, Oilgear Co., and R. G. DeLong, engineer, Twin Disc Clutch Co.

St. Louis Section

One of the most successful dinner-dances of the St. Louis Section was held on April 12 at the Algonquin Golf Club. More than 100 members and guests attended. L. W. Wallace, past vice-president of the A.S.M.E., delivered a very timely and thought-provoking address on "Whither the Engineer?" One of the features of this sixtieth-anniversary celebration was the presentation to the other members and guests of men present who have held membership in the Society for 20 years or more. These included Rudolph Schlatter, John R. Jackson, Dean A. S. Langsdorf, Walter Siegerist, and David Larkin.



ROUND-TABLE DISCUSSION MEETING OF A.S.M.E. MID-CONTINENT SECTION HELD IN ENGINEERS CLUB OF TULSA CLUB ROOM, MARCH 22, 1940. SUBJECT WAS "SAFETY FACTORS"

Schenectady Section

Schenectady Section observed the sixtieth anniversary of the A.S.M.E. during the week of April 7 when appropriate notices of the Society's history appeared in local papers.

South Texas Section

In commemoration of the sixtieth anniversary of the Society, the South Texas Section held a meeting on April 5 in Houston, Texas. Prominent guests included Warren H. McBryde, President, Ernest Hartford, assistant national secretary, and Dean W. R. Woolrich, manager, of the National Society. After an address by Mr. McBryde on "What Is Engineering and What Is Ahead for the Engineer?" the annual paper contest sponsored by the Section took place, with student members from Rice Institute, University of Texas, and Texas A.&M. College entered.

Toledo Section

Toledo Section participated in the national celebration of the founding of the A.S.M.E. with a meeting on April 11, at which N. R. Ohler, secretary-treasurer, gave a brief history of the Society. Guest speaker was G. D. Welty, development engineer, Aluminum Company of America, who spoke on "Development and Application of Aluminum Alloys."

Utah Section

The sixtieth anniversary of the founding of the A.S.M.E. was observed at the March 26 meeting of the Utah Section. Cathodic protection of natural-gas pipe lines was described by H. F. Hillard, chief engineer, Mountain Fuel Supply Co. A description of the method will be found in MECHANICAL ENGINEERING, March, 1940, on page 238.

Virginia Section

Warren H. McBryde, who is President of the A.S.M.E., was the guest of honor at the April 22 meeting of the Virginia Section in Richmond, Va. A dinner celebrating the anniversary of the Society followed a reception of the

SIXTIETH ANNIVERSARY MEETING A.S.M.E. WATERBURY SECTION, HELD APRIL 10, 1940, AT THE HOTEL ELTON, WATERBURY, CONN.
(At the head table, left to right: L. J. Niekerk, vice-chairman of Waterbury Section, R. W. Shoemaker, C. E. Davies, Secretary A.S.M.E., W. C. Schneider, chairman, Waterbury Section, J. R. Putnam, A. J. German, R. B. Bass, secretary, Waterbury Section, and R. C. Perry.)

A.S.M.E. chief officer given by several prominent local engineers.

Washington, D. C., Section

The nation's capital joined in the anniversary celebration on April 11 when the Washington, D. C., Section held a meeting at which papers were presented by student members from George Washington University, Catholic University, and the University of Maryland. Preceding the talks, Dean Frederick M. Feiker covered the growth and accomplishments of the Society. Refreshments suitable for the special occasion were served.

Waterbury Section

The meeting on April 10 of the Waterbury Section marked the anniversary of the Society. A short historical program was presented and appropriate remarks were made by National Secretary C. E. Davies. "A History of Clock Making in Connecticut" was given by J. R. Putnam, mechanical supt., Waterbury Clock Co. According to him, much of the early history of the brass history is connected with clock making.

Worcester Section

Worcester Section did its part in celebrating the A.S.M.E. anniversary on April 8 with a paper contest for student members at Worcester Polytechnic Institute. Three cash prizes were awarded to the winners. Clarke F. Freeman, member of A.S.M.E. Council, came from Providence, R. I., to give some of the historical high lights of the Society.

E.C.P.D. Petitioned to Study Accrediting of Nondegree Certificates

ALTHOUGH technical institutes and other nondegree technical programs in colleges are universally regarded as representing a necessary part of education for industry, it was claimed at a recent meeting in Pittsburgh by representatives from fourteen schools and institutes that the graduates of these courses are denied any recognition by civil-service commissions, the state licensing boards for engineers, or the Engineers' Council for Professional Development.[1] In line with this thought, the representatives of eleven of the institutions represented at the meeting authorized Parke R. Kolbe, president of Drexel Institute of Technology, to present the following petition to E.C.P.D.

"For many years leading authorities of the world of engineering education have emphasized the importance of the nondegree or technical-institute engineering program. They have encouraged the establishment of these schools as filling a definite need for men of a training shorter and less theoretical than that given in the degree-granting engineering college. At the same time, nothing has ever been done to recognize, accredit, or legitimize the certificate granted by this type of institution.

As a result, the graduates of these schools have found themselves, in many cases, at a definite disadvantage, since the training which they have secured receives little or no recognition from the engineering profession, as well as from many industrial employers who are naturally in doubt as to the meaning of the nondegree certificate. The representatives of the institutions here assembled do therefore petition the Engineers' Council for Professional Development, through its Committee on Engineering Schools, or such other appropriate committee as it may appoint, to institute a study of the nondegree programs, both day and evening, now existing in this country, and to devise and propose such a plan of recognition or accrediting as may seem wise and just."

After consideration of the foregoing petition at its April meeting, the Executive Committee of E.C.P.D. authorized J. P. H. Perry, chairman, to request the Council's Committee on Engineering Schools, under the chairmanship of Dean A. A. Potter, to appoint a special subcommittee to make a most careful study of the petition and to present a report after such study at the annual meeting of E.C.P.D., to be held in Pittsburgh in October, 1940. The Executive Committee also advised President Kolbe of Drexel Institute of Technology as to its action and added the statement that it was much interested in the relationship of technical institutes to the engineering profession and in the apparent need for some further recognition, in the form of accrediting or otherwise, of such institutes.

[1] Participating bodies include the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, The Society for the Promotion of Engineering Education, American Institute of Chemical Engineers, and the National Council of State Boards of Engineering Examiners.

Annual Meeting of S.P.E.E. in Berkeley, Calif., June 24–28

TAKING as its topic, "The Unfolding Obligations of Engineering Education," the 48th annual meeting of the Society for the Promotion of Engineering Education will be held at the University of California, Berkeley, Calif., June 24–28. The opening date is set so as to allow ample traveling time for A.S.M.E. members attending the 1940 Semi-Annual Meeting of their Society in Milwaukee, Wis., or Ann Arbor, Mich. In addition to the general sessions, several conferences will be devoted to the various fields of engineering.

Subjects to be discussed under the heading of mechanical and industrial engineering include heat-power and mechanical-engineering laboratory practice, machine design, manufacturing processes, engineering economy, mechanics, labor relations, and management. At the dinner of the mechanical-engineering division of the S.P.E.E., Warren H. McBryde, President A.S.M.E., will deliver the address.

A.S.M.E. Participates in Pan-American Science Congress

UPON the invitation of the United States Government, educational and scientific organizations, including The American Society of Mechanical Engineers, in 21 American republics participated in the Eighth American Scientific Congress, held May 10–18, in Washington, D. C. Representatives of the Society included Francis Hodgkinson, J. C. Hunsaker, J. P. Den Hartog, K. M. Irwin, C. J. McKnight, Louis Elliott, W. W. Nichols, W. L. Batt, Howard Coonley, Ralph E. Flanders, Charles E. Brinkley, W. C. Dickerman, J. D. Cunningham, W. A. Hanley, Alfred Iddles, James W. Parker, and K. H. Condit.

Summer Engineering Courses

University of New Hampshire

A SUMMER conference on engineering education will be held at the University of New Hampshire, Durham, N. H., July 8–20, under the joint sponsorship of the University and the Society for the Promotion of Engineering Education. The conference is planned for those men active in engineering education and engineering practice who may be interested in problems related to the present content and operation of engineering curriculums. Topics will be presented and discussed fully. Further details may be secured from Dean George W. Case of the College of Technology, University of New Hampshire.

Massachusetts Institute of Technology

A summer program of technical conferences and courses on research and practice on the frontiers of science and engineering will be conducted at Massachusetts Institute of Technology. This program, which supplements the regular summer courses for undergraduate and graduate students, will include four important conferences and thirteen special advanced courses.

A conference on "Friction and Surface Finish" will be held June 5–7 under the direction of Dr. J. C. Hunsaker, vice-president A.S.M.E., and head of the department of mechanical engineering.

The eighth international conference on "Spectroscopy" is scheduled from July 15 to 17. Included will be a discussion of the spectroscopic analysis of materials and other applications of spectroscopy to biology, medicine, chemistry, metallurgy, mineralogy, and industrial and engineering problems. Directing the conference will be Dr. George R. Harrison of the department of physics.

The solution of complex scientific and engineering mathematical problems with the aid of the M.I.T. differential analyzer will be the subject of a conference in the Institute's Center of Analysis, which is to be held under the direction of Dr. S. H. Caldwell, July 8–12.

Powder metallurgy will be discussed at a late summer conference from Aug. 29 to 31. This conference will bring to M.I.T. a group interested in the fundamental scientific and engineering problems of powder metallurgy, as well as the present state of industrial application and possible future developments and research necessary to advance this process. Dr. John Wulff will head the conference.

Among the courses to be given will be one on "Industrial Statistics," by Profs. G. P. Wadsworth and H. A. Freeman from Sept. 4 to 14. This course is intended for workers in industrial plants and scientific laboratories who would like to acquire the rudiments of modern statistical technique as applied to the design and analysis of laboratory experiments and to the control of the quality of industrial products. Included in the course will be lectures, discussions, and laboratory work.

To meet the growing interest in photoelasticity, the department of mechanical engineering at M.I.T. is sponsoring a short summer course dealing with this method of stress analysis. The course will be held from July 22 to Aug. 2, inclusive. Additional information may be obtained from Dr. W. M. Murray.

Further information about these conferences and courses may be obtained from Prof. Raymond D. Douglas, chairman of the summer session at the Institute.

Stevens Economics Conference

The tenth annual Economics Conference of Stevens Institute of Technology will be held at the school's camp at Johnsonburg, N. J., June 22–30. Four series of morning conferences will be offered covering the subjects of management control, industrial psychology, applied economics, and labor. In the evenings, the more than 150 participants will gather to listen to talks given by outstanding engineers and industrialists.

University of Michigan

Starting June 21, there will be offered as a part of the 1940 summer session of the University of Michigan, the "Internal-Combustion Engine Institute," consisting of a special eight-week lecture, conference, and laboratory program, which will cover the fundamental principles of both theory and practice of the internal-combustion engine. In the parallel subject of thermodynamics a special advanced course as applied to the problems of the internal-combustion engine is also being offered by the University.

American Engineering Council

Presents

The News From Washington and Elsewhere

Court Upholds Wage Rules on Federal Contracts

IN A decision openly critical of judicial interference with administrative procedure the U. S. Supreme Court on April 29 upheld the action of the Department of Labor in setting minimum wage rates for steel companies desiring to bid upon government contracts.

The case arose from the enforcement of the Walsh-Healey Act, which provides that successful bidders on government contracts amounting to $10,000 or over must pay prevailing wages current in the locality in which the goods are produced. In accordance with its provisions the Department of Labor had ruled that steel companies in the "locality" comprising the thirteen Northeastern States, the District of Columbia, and part of West Virginia must pay not less than $62\frac{1}{2}$ cents per hour for labor engaged in fulfilling government contracts. This was attacked by a number of steel companies which contended this rate, admittedly prevalent in the Pittsburgh district, should not be extended over so extensive an area. Their contention was upheld by the District of Columbia Court of Appeals, which over a year ago granted an order suspending the ruling.

The Supreme Court, however, ruled that the federal government "enjoys the unrestricted power to produce its own supplies, to determine those with whom it will deal and to fix the terms and conditions upon which it will make needed purchases." It also criticized the lower court for its "departure into fields hitherto wisely and happily apportioned . . . to the administration of another branch of our government" with the result that in the steel industry "the act has been suspended and inoperative for more than a year." During this period, the Court pointed out, the demands of national defense have made it necessary to award contracts for more than $65,000,000 in iron and steel products without the protection of the declared policy of Congress.

As a practical matter, it is impossible in the average steel mill to segregate labor engaged upon government work from that on commercial orders. It is therefore necessary for a mill either to apply the government wage scale to all its operations or to forego bidding upon federal contracts.

Transportation Problem Before Congress

Government planning for future needs and state and local tax relief for the railroads were primary points urged for the relief of the transportation problem in a comprehensive four-volume report recently transmitted to Congress by Joseph B. Eastman, chairman of the Interstate Commerce Commission. The study was begun several years ago by Mr. Eastman as Federal Coordinator of Railroads, a post that was allowed to lapse, and has been completed by the ICC under his direction. Public aid which, in many instances, resulted in little public benefit was assessed in the report with much responsibility for the present surplus of transport facilities. Other factors mentioned are technological changes and unnecessary duplications of facilities.

Probable expenditures for transportation facilities, Mr. Eastman estimates, will aggregate $6,000,000,000 by 1950. Continuation of the present system of federal grants will, he warns, perpetuate the conditions of uneconomic competition now perplexing transportation students. In its place, he recommends the creation of a three-man board by the President to investigate the problem of inequities in public contributions and to perform "deliberate and calculated" planning to meet future transportation needs through the mediums best adapted to serve them. Regulation, he points out, can do much to make such

planning effective, or alternately to frustrate attaining its objectives.

On the subject of taxes Mr. Eastman holds that the highway carriers have, since 1927, been paying their own way (a conclusion that is vigorously contested by the railroads) and that railroads are taxed somewhat more heavily than are competing forms of transportation. With minor exceptions federal taxation is not a problem; what is needed is simplification and reduction of state and local taxes. He recommends the repeal of provisions of the land-grant acts that require the railroads to carry mail, troops, and government property at reduced rates on the ground that during the 85 years that these have been effective the initial subsidy granted the railroads has been more than repaid.

TNEC Finds Job Problems But No Simple Answer

Three weeks of hearings were completed April 26 by the Temporary National Economic Committee on the broad subject of technologic change and its effect upon employment. Much detailed testimony was presented to the effect that mechanization of industry, while it reduces prices and thus stimulates production and employment, nevertheless, brings distress and loss of earning power to thousands of individuals and even entire communities. While numerous palliative measures were suggested, no witness came forward with a clear-cut plan for solving this difficulty.

So voluminous a hearing cannot be adequately reviewed in the brief space here available. In general, the witnesses fell into three classes: Economists who presented extensive facts and figures on broad trends in industry and society; industrial executives who stressed the public benefits derived from technical progress; and labor leaders who cited specific cases of technological displacement.

In opening the hearings Chairman O'Mahoney stated: "The 10 years since the crash of 1929 have probably seen the establishment of more new industries, and greater technological gains in old industries, than any decade since the human race first began to measure time. . . . The same decade has been notable for its steady demand upon Congress for ever larger appropriations to provide work for the unemployed. . . . Unemployment of men, unemployment of money, unemployment even of the machine which technology has developed, remains an unsolved problem."

The first day was devoted largely to a presentation by the committee's economic adviser, Dr. Theodore J. Kreps, of Stanford University, who sketched the history of technical progress and discussed some of its more important economic and social problems. Technology was broadly defined to include "all innovations in the arts of production and trade brought about by science, invention, and scientific management." Technical developments, he pointed out, are the result of increasing scientific knowledge and "it is entirely probable that we are today on the threshold of a greater period of technological advance than ever before."

New machines and new methods are introduced primarily, Dr. Kreps stated, to reduce costs; displacement of labor, while often a result, is seldom a motive. In a sample check of inventions only a third were found to result in the saving of labor; 45 per cent in the creation of new kinds of consumers goods; 14 per cent in the saving of capital; 8 per cent in the saving of land.

Since 1870 physical production per worker has more than doubled, the work-week has been reduced from 70 to 40 hr, wage rates have increased, and invested capital per worker has multiplied more than tenfold. But since 1910, and particularly since 1925, there has been a marked increase in the adoption of capital-saving inventions—cheaper machines capable of the same, or even greater, production than the more expensive units they replace. In the iron and steel industry a typical furnace that produced a daily output of 302 tons in 1929 now yields 395 tons; in the cotton industry production per spindle has increased from 276 sq yd per spindle in 1929 to 410 in 1939; with no diminution in capacity, fixed capital in the automobile industry has decreased more than 20 per cent since 1926.

Even during the thirties capital investment has not been hesitant in lines where it was needed. In such expanding fields as rayon, electric refrigerators, and several chemical industries productive capacity has more than doubled. But what industry as a whole needs is not more capacity, but more markets. Generally speaking, American industry is now equipped to serve a national income of from 90 to 100 billion dollars.

Before 1914 the benefits of technology were, on the whole, passed on to consumers in the form of lower prices; as a result 112 men were hired for every 100 men displaced. During the prosperous years 1923 to 1929 only 91 men were hired for each 100 displaced. The conclusion that something has happened to prices since the World War which has prevented the benefits of technology from being fully distributed to consumers has been reached by many authorities. The advance of some 30 per cent in man-hour output in manufacturing industries since 1929 is only partly reflected in prices today.

"There are two frontiers—the industrial frontier and the frontier of economic adjustment. Changes in one must be synchronized with changes in the other. If we vigorously push advances in technology and refuse to make the requisite economic adjustments we will set up grave tensions in our society. Obviously, to call a moratorium on research or on progress is both unwise and impossible. But the shortsightedness of those who argue that the industrial frontier is gone is only exceeded by the stupid defeatism of those who wish to call a halt to economic adjustment."

Following this opening presentation and a survey of new and impending technological changes by Watson Davis, editor of *Science Service*, the committee heard a large number of witnesses from various industries, including transportation, iron and steel, business machines, and agriculture. In the latter field, officials of the Department of Agriculture disclosed that the number of persons employed in agriculture has dropped from 12,209,000 in 1910 to 10,629,000 today, although farm population has remained stable at approximately 32,000,000 and the nonfarm consumers fed by the products of the farms have increased from 58,000,000 to 99,000,000. Approximately half of this increase in productivity is attributed to the tractor and kindred technological improvements; the balance to better soil practices, fertilizers, seeds, and superior management.

FPC Publication Details Utility Statistics

Comprehensive facts regarding all public-utility companies in the United States receiving annual electric incomes of $250,000 or more, representing 95 per cent of the industry, are contained in a new publication of the Federal Power Commission, "Statistics of Electric Utilities in the United States, 1938," available at two dollars a copy from the Commission. The 500-page volume reports official figures from detailed returns made to the Commission as required by law. A similar volume was issued last year.

The 393 electric utility companies listed have total assets aggregating $17,220,617,262; utility-plant accounts totaling $14,048,019,026; outstanding securities amounting to $13,546,254,340.

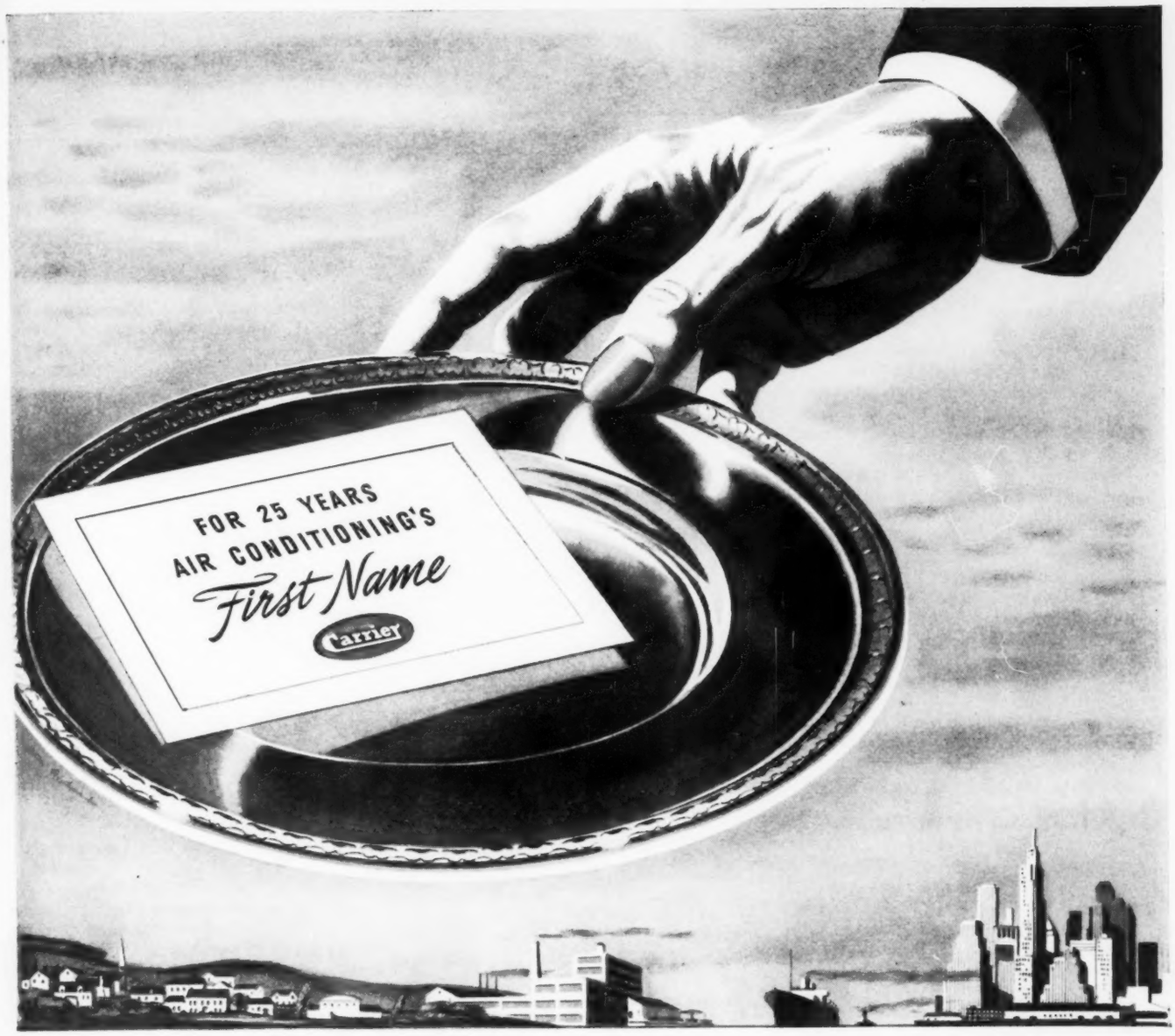
New Bureau to Study Job Possibilities

Financed by an appropriation of $70,000, a new unit to be known as the Occupational Outlook Service is now being set up in the Department of Labor under the direction of Chief Economist A. F. Hinrichs. Its purpose will be to study trends in technological employment, shifts in employment by industries, and changes in opportunities in the professions, with particular attention being devoted to "blind alley" jobs that offer little promise of promotion. For the time being the service will be useful primarily to placement directors and others interested in vocational guidance, but later it is hoped to expand its usefulness by advising individual job seekers, particularly youths seeking first employment, as to promising fields. Present plans envision a staff of about 25 persons headed by a director whose selection is imminent.

U. S. Trying to Define Professional Status

Redefinition of the executive, administrative, and professional groups legally exempted from provisions of the Fair Labor Standards Act is currently being studied by the Wage-Hour Administration of the Department of Labor. The question arose as an incident to hearings on the wholesale distributive industries, which has a number of technical employees, but is of interest to professional groups because any definition arrived at would probably be extended to other industries. Considerable testimony suggesting various definitions, broad and narrow, was presented, but a final determination has not yet been announced.

(*A.S.M.E. News continued on page 512*)



CARRIER CELEBRATES ITS SILVER ANNIVERSARY

No man in industry needs to be told of the progress that Carrier Air Conditioning and Carrier Refrigeration have brought about. They have showed the way to better business and more profits through improved processes with more accurate control.

Many still regard Air Conditioning as but a lusty infant. And yet—

★ The *first* air conditioning installation was made but a few years after the turn of the century, by Willis H. Carrier.

★ As long ago as 1911, Mr. Carrier presented his famous Rational Psychrometric Formulae, the basis of modern air conditioning.

★ In 1915 the present Carrier organization was founded, to put into wide practice the principles of this modern science.

1940 is the silver anniversary of air conditioning's coming of age... the 25th year of the Carrier organization. Thanks to the knowledge gained in a quarter-century of development and experience in 99 countries, there is but one rule for you to follow: call air conditioning by its *first name*...call *Carrier*. Representatives are listed in the classified section of your phone book.

Carrier

Visit the Carrier Igloo of Tomorrow at the New York World's Fair.

CARRIER CORPORATION DESK 12F
SYRACUSE, NEW YORK
"Weather Makers to the World"
(In Canada, 30 Bloor St. West, Toronto, Ontario)

Please send me complete information on Carrier Air Conditioning.

NAME_____

COMPANY_____

ADDRESS_____

Men and Positions Available

Send inquires directly to
Engineering Societies Employment Service
29 West 39th St., New York, N. Y.

MEN AVAILABLE[1]

PRODUCTION ENGINEER, 27, single. Johns Hopkins, 1932, mechanical engineering. Excellent background in automobile production, shop-plant layout, motion-analyzed material-handling systems, production and efficiency methods. Desires connection in time-study and methods department. Me-467.

RESEARCH ENGINEER OR METALLURGIST, 32, married. Wide experience in steel-fabricating industry including design, development, and production engineering. Familiar with all aspects of arc and Unionmelt welding. Me-468.

RECENT GRADUATE, Purdue, 24, married. Desires to change position. One year mold design, 3 years' technical laboratory experience. Would like work in steam or heat power field. Location, secondary. Me-469.

MECHANICAL-ELECTRICAL ENGINEER, DESIGNER, 29, married. Four years pregraduate mechanic and electrician; 5 years responsible electrical and mechanical maintenance; 1½ years successful inventive design. Travel; go anywhere. Me-470.

MECHANICAL ENGINEER, 23, single, B.S., 1939. Four years' experience as engineering draftsman, inspector, machinist; now employed. Managerial ability. Desires traineeship in design. Location, immaterial. Me-471.

MECHANICAL ENGINEER, 37, Lehigh, 1923. Production, power, and maintenance; varied experience in industrial, plant engineering. Registered professional and operating engineer. Me-472.

MECHANICAL ENGINEER, single, 23. Sound technical and practical training in engineering fundamentals. Desires opportunity for experience leading to responsible engineering position. Interested design, testing, production work. Available June 1, 1940. Me-473.

COMBUSTION ENGINEER, M.I.T. graduate. Sixteen years' experience, design, operation of steam plants, wide knowledge of coals. Desires position large coal producer, consulting engineer, or equipment manufacturer. Me-474.

STEVENS GRADUATE. Fifteen years' sales experience in New York in heating, ventilating, air-conditioning, and power-plant equipment fields. Also experienced design of heating, ventilating, air-conditioning systems. Me-475.

ASSISTANT PRODUCTION ENGINEER, single, honors graduate. Two years machine-shop apprentice; 15 months works manager's assistant in production of internal-combustion engines and gears. Fast draftsman, good organizer. Me-476.

MANUFACTURING PLANT MANAGER OR SUPERINTENDENT, organizer, coordinator, thoroughly conversant all plant activities, controls for materials production and costs. Background of industrial engineering experiences in mechanical- and electrical-products plants and in process industries. Me-477.

[1] All men listed hold some form of A.S.M.E. membership.

MECHANICAL ENGINEER, 39, Pennsylvania registration, two degrees. College teaching experience. Practice in selection of power-plant equipment, combustion-engineering and heat-balance problems. Proficient technical writer. Available June 1. Me-478.

MECHANICAL ENGINEER, Cornell. Twenty-three years' experience design, development, manufacture; automotive, industrial, and marine engines, compressors, pumps, clutches, gearing; 15 years responsible charge. Inventive ability. Desires executive design position related field. Me-479.

PLANT SUPERINTENDENT, 32, married. Experienced in economical manufacturing of products using sheet metal, structural steel, and castings in their construction. Now employed, available reasonable notice. Me-480.

PRODUCTION ENGINEER, B.S.M.E., age 23, single. Experienced in cost analysis, scheduling, and production work in large shipbuilding plant. Now employed. Desire connection with shipbuilding or airplane plant. Me-481.

POSITIONS AVAILABLE

GENERAL SALES MANAGER with full knowledge of industrial problems and thorough experience in all phases of metal-stamping field. Only man who has held responsible position as director large sales organization will be considered. Location, New England. Y-4524.

MECHANICAL ENGINEER with 8 to 10 years' experience covering heating and ventilating, particularly in respect to industrial processes, steam-power theory, and practice. As work will be greatly diversified, it is probable that general industrial engineering would be of value. Salary, $3000–$3500 a year. Location, New Jersey. Y-5670.

GRADUATE MECHANICAL ENGINEER, preferably 30–35, with several years' previous experience in selling steel products and/or general machinery for export sales work in metropolitan area. Knowledge of foreign languages helpful. Salary, $300 a month. Location, New York, N. Y. Y-5671.

INDUSTRIAL ENGINEER, 35–40, about 10 years out, with good executive experience for company manufacturing cosmetics. Location, New York State. Y-5680.

GRADUATE MECHANICAL ENGINEER with background of selling experience in following lines: centrifugal, deep-well, and power pumps, steam engines and boilers, sewage aerators and distributors, heat-transfer equipment, Cochrane deaerators, heaters and water softeners, steam turbines, etc. Territory, central and northern New York State. Y-5682.

TOOL AND DIE ENGINEER, 35–45, for design and development of new precision punches and dies for simple, compound, and progressive operations on presses used in fabrication of small, intricate, close-tolerance metallic parts. Applicant must have thorough practical and technical knowledge of design and construction of tools and dies similar to those mentioned and should have at least 10 years' experience in design and development problems. Experience must have been acquired in industries manufacturing such products as watches, cash registers, typewriters, small instruments, or electrical appliances. Applicant should be of analytical type and have ability to cooperate with others. Salary, $400 a month. Location, East. Y-5683.

SALES MANAGER for flowmeter division. Must have flowmeter sales experience. Salary, $4000 a year. Location, East. Y-5695.

SALES MANAGER, 35–45, with proved ability in direction of national sales organization to act as sales representative to introduce new product in printing and publishing field. Must be able to analyze accurately and discuss intelligently printing costs, processes, and production problems. Salary, $7500–$10,000 a year. Location, New York metropolitan area. Y-5708.

PRODUCTION SUPERINTENDENT with experience in manufacture of printing presses. Location, New York, N. Y. Y-5712.

INSTRUCTOR, young, thoroughly grounded in heating and ventilating, with some educational experience, for midwestern institution. Y-5728-C.

SALES ENGINEER, 28–40, with thorough and successful career in sales field. Must be energetic, forceful, and have earned at least $5000 a year. Knowledge of steam and process industrial problems and hydraulic metering beneficial as applicant will be required to work out difficulties in the field. Salary, $5000 a year. Location, New York metropolitan area. Y-5729.

ASSISTANT PRODUCTION SUPERINTENDENT, 40–45, to handle special production assignments in foundry and machine shop. Foundry work highly technical as company has malleable cast-iron and special alloy-steel work. It may be necessary to divide this position between two men, one foundry specialist and one machine-shop specialist. Salary, $300–$400 month. Location, Illinois. Y-5730-R787-C.

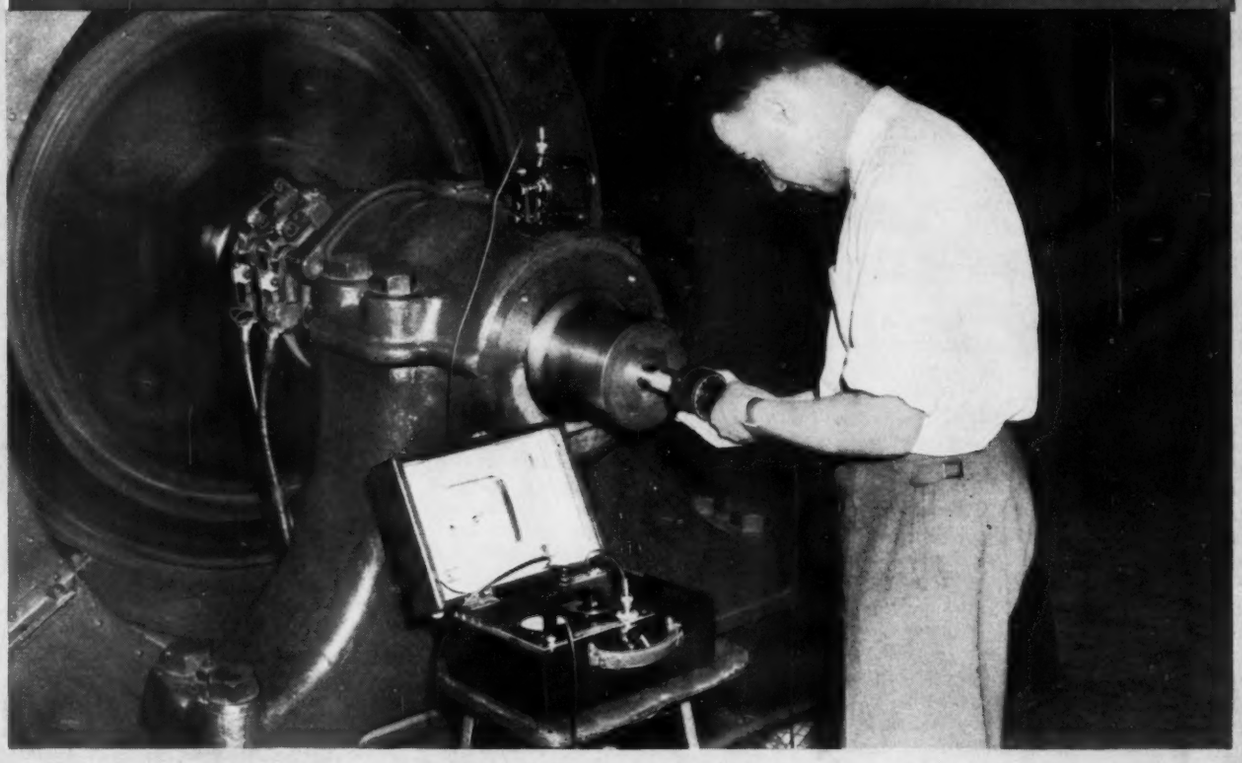
PATTERN SHOP SUPERINTENDENT, about 40, to take charge of wood and metal patterns. Experience in miscellaneous pattern work, preferably in heavy-goods industry as there will be patterns on valves, fittings, and plumbing goods. Candidates of good background and good personality who are able to reduce costs and get along well with employees preferred. Salary, $4000–$4500 a year. Location, Illinois. Y-5731-R788-C.

GRADUATE ENGINEER for purchasing department, not over 35, good appearance and personality. Must have several years' experience in purchasing items for all phases of mechanical departments in plant maintenance as well as items used in production; should also have some knowledge or experience in printing and purchasing of office items such as forms, stationery, etc. Location, New York State. Y-5735.

PROCESS ENGINEER, either electrical, mechanical, or industrial, with experience in designing and developing of all factory processing equipment and capable of investigating and overcoming various factory-product processing troubles. Salary, $200–$250 a month. Location, Middle West. Y-5736C.

(A.S.M.E. News continued on page 514)

To Measure—BALANCE ELECTRICALLY



HOW simple would you say it is to balance a 50-ton alternator rotor moving at 3600 rpm until its vibration is less than three ten-thousandths of an inch—or one-tenth the diameter of a human hair? Not very, you say? Well, a little while ago you may have been right. Today you're wrong.

For while heretofore the balancing of large rotating machines was a long, drawn-out procedure, perhaps requiring the removal of the rotors from the machines, now there is a portable G-E instrument that does the job simply, quickly, and under actual operating conditions. And on a 20,000-kva synchronous condenser, for example, balance can be achieved with as few as three runs—which is a far cry from the 100 to 170 trials which were frequently necessary before.

In simple terms, the balancer consists of a hand-held sine-wave alternator, a vibration pick-up, and an instrument. These provide the essential measurements, which are made both before and after trial weights have been placed in chosen balancing planes. By interpretation of the facts thus obtained, almost perfect balance of the machine can be achieved.

Here, then, is another portable, precise, electric instrument for the measurement of a nonelectrical quantity. It joins the ranks of G-E instruments developed to measure the surge of lightning, the trickle of electrons in a vacuum—instruments to analyze color exactly and to unscramble and measure sound waves.

The contributions of G-E engineers to its development were made possible by years of research and a half-century of experience in every field of electrical endeavor. And yet they represent no more dramatic achievement, really, than that of providing accuracy and dependability in the complete line of G-E instruments for the measurement of electrical quantities—current, voltage, resistance, watts, frequency, power-factor—in dozens of styles, indicating and recording, and in ratings to fill every need. That's why, if your problem involves measurement, you should remember General Electric, Schenectady, New York.

HEADQUARTERS FOR ELECTRICAL MEASUREMENT

GENERAL ELECTRIC

430-160

RECENT GRADUATE MECHANICAL ENGINEER, three or four years out, for research work in cordage. Salary, $1700 a year. Location, New England. Y-5802.

METHODS ENGINEER who is thoroughly acquainted with lumber trade and capable of working up costs through accounting department. Later to go to mill to develop methods and equipment to effect methods. Man who accepts this position must have broad managerial experience and be able to establish accounting procedures as well as methods. Location, West. Y-5738-CS.

DESIGNING ENGINEER, about 45, with executive ability to carry through to completion design of light machine involving some 4000 intricate parts, including light metal stampings, gears, cams, shafting, etc. Must be capable of directing field tests and supervising cost estimating. Applicant must have had 5 to 10 years' experience in design and development of light machinery such as typewriters, adding machines, etc. Salary, $300–$350 a month. Location, New England. Y-5756.

SALES MANAGER for machine-tool trade, to head large sales district such as metropolitan New York. Headquarters, N. Y. C. Y-5763.

PLANT ENGINEER, about 40, graduate mechanical or electrical, who has had experience in construction, layout, and maintenance of buildings. Some traveling. Salary, $60 week. Headquarters, New Jersey. Y-5764.

ASSISTANT MANAGER, 35–40, graduate mechanical engineer, with several years' industrial experience. Should have fair experience on business side of engineering and sales personality as position will require considerable contact work with customers. Salary, about $75 week. Excellent opportunity. Location, Pennsylvania. Y-5786.

SAFETY ENGINEER able to write publicity matter and also follow legislation in the several States. Position will be largely contact work. Salary, about $3000 a year. Location, New York, N. Y. Y-5787.

WORKS MANAGER, 35–40, familiar with machine design, production control, costs, etc. Must be willing to do own drafting. Scandinavian preferred. Salary open. Location, New York, N. Y. Y-5800.

MECHANICAL ENGINEER with cap or can experience. Must have supervisory ability and experience in stamping, forming, and drawing on light metals. Salary open. Location, New York metropolitan area. Y-5814.

INDUSTRIAL ENGINEERS. Men should have from four to ten years' experience in industrial-engineering work, namely: job evaluation; time study and rate setting; wage incentives, method and cost-reduction studies; cost analysis; mill planning and scheduling; standards setting and cost-control work, relating directly to standard cost installation. Should have experience, personality, and aptitude for steel-mill operations. Salary, $225–$400 a month. Location, East. Y-5816.

GRADUATE MECHANICAL ENGINEER for engineering publicity work. Company will consider recent graduate if he has good background in mechanical-engineering subjects and an aptitude for writing accurately with good diction; however, an engineer with experience is preferred. Work will consist of writing descriptive literature on air compressors, Diesel engines, and associated mechanism, making computations on performance, compiling data, making instruction drawings, and arranging other material for catalogs, instruction books, and the like. Applicant should forward application outlining qualifications, accompanied by a letter in own handwriting applying for position. Location, East. Y-5827.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after June 25, 1940, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references.

Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and transfer to Member.

NEW APPLICATIONS

For Fellow

PRINCE, DAVID C., Schenectady, N. Y.

For Member, Associate, or Junior

ACKLEY, ROBT. A., Chicago, Ill.
ALBRIGHT, C. MONROE, JR., Wallingford, Pa. (Re)
BEATY, ALDEN Q., Spencer, N. C. (Re)
BLOSS, WM. S., Buffalo, N. Y.
BURNS, LOUIS G., East Cleveland, Ohio (Re)
CHRISTENSEN, BOYD E., Oklahoma City, Okla.
DOLL, EMIL, West New York, N. J.
DONNELLY, FRANCIS J., Brooklyn, N. Y.
FLOYD, COLUMBUS, New Orleans, La.
FOEHL, JULIAN A., East Rutherford, N. J.
GRABOSKI, LEO D., Wilkes-Barre, Pa.
HAYDON, ARTHUR W., Forestville, Conn.
HORTON, T. A., Niagara Falls, N. Y. (Rt)
JACKSON, ROBT. L., Philadelphia, Pa.
JOHNSON, CARL E., Pittsburgh, Pa.
KENNON, LORENZO, Burbank, Calif.
LONTZ, D. M., Watertown, Mass. (Rt & T)
LUM, W. O., Bloomfield, N. J.
MATTING, FRED WALTER, Manhattan, Kan.
McARTHUR, RALPH F., Huntington Park, Calif.
MESSICK, GEO. B., Philadelphia, Pa.
NOOR, ROBT. A., Tuscumbia, Ala.
ORTH, HARRY R., Kansas City, Mo.
PARDUE, NORMAN C., Birmingham, Ala.
PETRESCU, O. S., Waynesboro, Va. (Rt & T)
PIERCE, BRISTER B., Bogalusa, La.
PIERCE, HARRY M., Wilmington, Del. (Rt)
RILEY, BENJ., Worcester, Mass. (Re)
ROSHONG, RAYMOND G., Los Angeles, Calif.
SANDISON, A. G. S., N. Tonawanda, N. Y.
SELIG, ERNEST T., JR., Kansas City, Mo.
SCHENK, EINAR S., Honolulu, T. H.
SIGNORET, A. J., Stony Brook, L. I., N. Y.
WEISBEIN, JACK, Kansas City, Mo.
WEISS, CHAS. R., Indianapolis, Ind.
WYER, RAMON, Baltimore, Md.

CHANGE OF GRADING

Transfer to Fellow

MOSS, SANFORD A., W. Lynn, Mass.
REYNOLDS, HERBERT B., New York, N. Y.

Transfer to Member

BLACKSTONE, F. B., Port Sulphur, La.
BLADE, ELLIS, New York, N. Y.
OBERHOLTZER, ROBT. E., Plymouth Meeting, Pa.
PRATT, J. H., Oak Park, Ill.
SHELDON, WM. D., JR., Galt, Ont.
SPAULDING, HAROLD S., Alhambra, Calif.

A.S.M.E. Transactions for May, 1940

THE May, 1940, issue of the Transactions of the A.S.M.E. contains the following papers:

TECHNICAL PAPERS

Characteristics of Cloth Filters on Coal Dust–Air Mixtures, by A. R. Mumford, A. A. Markson, and T. Ravese

Mean Temperature Difference in Design, by R. A. Bowman, A. C. Mueller, and W. M. Nagle

Automatic Control in the Presence of Process Lags, by C. E. Mason and G. A. Philbrick

The Influence of Crystal Size on the Wear Properties of a High-Lead Bearing Metal, by J. R. Connelly

Calculation of the Elastic Curve of a Helical Compression Spring, by H. C. Keysor

Helix Warping in Helical Compression Springs, by D. H. Pletta and F. J. Maher

Boundary Film Investigations, by S. J. Needs

High-Speed Lightweight Trains, by C. T. Ripley

Necrology

THE deaths of the following members have recently been reported to the office of the Society:

BARSTOW, FRANCIS L., March 28, 1940
BEAUSOLEIL, RAYMOND J., January 12, 1940
CHRISTIANSEN, PAUL, April 10, 1940
DALLETT, ELIJAH, December 1, 1939
DU BOSQUE, FRANCIS L., April 13, 1940
HALL, WILLIS M., February 17, 1940
LEACH, HARRY E., March 21, 1940
POWELL, IVAN E., March 24, 1940